Popular Astronomy

Vol. XLIX, No. 5 MAY, 1941 Whole No. 485

Frank Craig Jordan
1865-1941

By OLIVER J. LEE

FRANK CRAIG JORDAN

Only the finest things can be said about Frank Jordan, and all of us who knew him want to say them again out loud.

Frank Craig Jordan, an only child, was born at Cordova, Illinois, on September 24, 1865. In giving her son to the world his mother, Louisiana, forfeited her own life. Soon thereafter his father, John Henry, took him to a sister's home in Beverly, Ohio, where they lived for many years.

His caliber as a student and man was revealed at Marietta College where he was graduated in 1889 with Phi Beta Kappa honors. He was a member of Alpha Sigma Phi fraternity, served as president of his class and figured prominently in athletics and other activities in the Marietta community.

Following his graduation he taught in Marietta Academy for a brief period before going as instructor to Linsley Institute in Wheeling, West Virginia. Returning to Marietta in 1890 he remained for ten years as instructor in mathematics and astronomy.

Then came the call of the far northwest. He responded and served two years as principal of a high school in Portland, Oregon. Then returning eastward, he served as principal of the high school at Colorado Springs for the period 1902-1905. His next move was to the Yerkes Observatory, Williams Bay, Wisconsin, where he matriculated in the autumn of 1905 in preparation for his doctorate under the stellar-photometrist, John Adelbert Parkhurst. Here he entered upon the field which was to become his primary research interest, variable stars. Each of the two men al-

ways spoke of the other with deep understanding and affection. The record shows that Jordan was Fellow in Astronomy during the autumn and winter quarters of 1907-8.

When Jordan and I met in the late summer of 1907 we soon became friends and companions. Jordan lived in a small frame house near the observatory, and as summer turned to colorful autumn and autumn to sterner winter we took many long walks together and skated endless miles on Lake Geneva. The Indians had called it Kish-woc-ke-toc (Big Foot). Cloudy nights, when neither could make astronomical observations, brought us together at Jordan's house. We soon started a series of cribbage games which ran all that long winter. Even now it is easy to remember that the series comprised 2674 games and that the average hand yielded 6.473 points and the average "widdy" 5.129 points. Promptly at midnight the playing would stop and we would make and enjoy a feast of waffles with Ohio maple syrup before I left for my own quarters.

Jordan's studies for his degree were interrupted by another move. To quote Dr. Frank Schlesinger, "Dr. Jordan joined our staff at Allegheny in 1908. I had met him the year before during a visit to the Yerkes Observatory and was deeply impressed by his ability as an observer and by his sterling qualities of character."

He remained as assistant professor at the University of Pittsburgh from 1908 to 1919 when he was made professor under Dr. Schlesinger. In the fall of 1928 he became assistant director with Dr. Heber Doust Curtis. On October 15, 1930, he succeeded Dr. Curtis as Director of the Allegheny Observatory.

Marietta College gave Jordan a Master's Degree in 1892 and the honorary Doctorate of Science in 1929. The University of Chicago awarded him the degree of Doctor of Philosophy on August 28, 1914.

On June 22, 1893, Jordan married Miss Clara A. Ross of Beverly. Two children were born of this marriage, both in Marietta. The first, a daughter, lived only a few hours. Later came a son, Frank Warren, who died at about three years of age in Spokane, Washington. Mrs. Jordan was ill for a number of years and her condition was largely responsible for their going to Oregon and later to Colorado. She died on April 4, 1907, in Marietta.

During his first year at Allegheny Jordan renewed his friendship with Mrs. Harriet Caywood Roy whom he had known in college days. They were married on November 25, 1909. Their son, John, was graduated from Marietta College in the class of 1934 and survives. This marriage was a singularly happy one. Its end in the tragic death of both between the hours of six and seven in the evening of February 15, 1941, produced a sense of terror,—of crass injustice done,—in their wide circle of friends. Mrs. Jordan had been confined to the house for some days with heart trouble, but was able to get to the window and call for help.

From an excellent report of events at the Jordan home by Mr.

Nicholas A. Phelan, Chief of the Fire Bureau in Pittsburgh, the following details may be excerpted to answer various questions naturally arising in the minds of their friends.

After driving back the fire and cooling the walls and windows with water, the firemen brought out the body of Mrs. Jordan from the front room on the second floor. Other firemen broke in the cellar door and found Jordan lying against it. Nobody knew about his being in the cellar until they found him there. "After an investigation the Battalion Chief in charge of the firemen who responded to this alarm stated that the probable cause of the fire was a coal gas explosion, that is, Dr. Jordan probably went to the heating furnace in the basement and opened the door, which allowed a gaseous accumulation to escape, causing an explosion and fire which immediately engaged the premises."

Except for a highly productive side excursion into stellar spectroscopy between the time of his arriving at Allegheny in 1908 and 1916, Jordan's main field of research was variable stars. Seventeen papers, eleven of them orbits of spectrographic binaries, date from these eight years.

Three papers by Parkhurst and Jordan (*Astrophysical Journal,* Vols. 23, 26, and 27, 1905, 1907, and 1908) laid foundations for determining magnitudes and colors of stars by photography. The first carried the title *Photometry of Short-Period Variable Stars.* The second, *An Absolute Scale of Photographic Magnitudes of Stars,* developed a method of reducing the opacities of extra-focal images of stars by means of sensitometric areas impressed upon the stellar photograph. The third paper, *The Photographic Determination of Star-Colors and their Relation to Spectral Type,* initiated the method of obtaining the color indices of stars by photographing them "almost simultaneously" upon ordinary blue-sensitive and isochromatic plates, a yellow filter being used with the latter to cut off the blue light which alone was active with the former. This method has been used extensively since that time. (A satisfactory commercial panchromatic plate had not yet been produced.) Up to this time photographic magnitudes of stars had been compared with visual measures in order to get color indices, which were found by Parkhurst and Jordan to be vitiated appreciably by the Purkinje effect. They first established that a linear relationship exists between the colors of stars, as determined entirely by photography, and spectral types. Jordan's doctoral thesis. *Color Changes in Variable Stars* (*Astrophysical Journal* **50**, p. 174, 1919) continues the investigation described in the last paper and applies its methods to four variables having periods from 8 to 16 days, and establishes in each case "that the star becomes redder as it becomes fainter, indicating some change in its spectrum." He concludes that "—the expressions 'photo-visual magnitudes' and 'photo-visual light curve' can be properly applied to such results."

Throughout his career at Allegheny from the time of completion of the great thirty-inch Thaw Photographic Refractor until about five

years ago Jordan kept up his photometric program. He used the method of extra focal images. Volume VII of the *Publications of the Allegheny Observatory* (1929) is entirely by him. It contains the definitive light curves of 29 Cepheid variables and 16 eclipsing binaries with searching discussions of all the rich data involved. At the time of his death several more such light curves were quite or nearly ready for publication. These results and other materials will be published as a memorial volume to Jordan.

To quote Dr. Schlesinger again, "His contributions to our knowledge of the light curves of short-period variable stars are very important and will become more so when the question of secular changes in these light curves is taken up in the future," and Dr. Heber D. Curtis, "I rather think that his work in this line [photometry of variables] has been surpassed only by the photo-electric cell."

Jordan, like Barnard, loved to observe and his skill and enthusiasm were easily enlisted in the larger programs under way both at Yerkes and at Allegheny.

When Dr. Frederick Slocum began his stellar parallax work at Yerkes in 1909 he found and used a number of superb plates taken with the 40-inch telescope by those indefatigable observers Frank Jordan and Philip Fox. In 1914 when the writer began the measurement of stars around the Systematic, Selected Centers of Kapteyn he also found Jordan and Fox plates which were very valuable for proper motions because they had "aged."

The following quotation from Keivin Burns' short obituary of Jordan in *Science*, February 28, 1941, is significant. "In the first decade of the work of the Thaw Refractor the exposures [of parallax plates] were short, and the time required to change from one object to another was of importance. In this period 35,000 plates were secured, 12,000 by Jordan. On the basis of the average of other observers his share would have been 9,000. His great number of plates was not due so much to the enthusiasm with which he watched for breaks in the clouds as to the remarkable efficiency of his unhurried speed."

Curtis remarks, "His [Jordan's] quickness in observing was rather unusual, yet it was accomplished with no apparent hurry or fuss; merely by making every motion count. Both Burns and I have been around a bit and are willing to admit that we are pretty good when it comes to observing or manipulating instruments. But Jordan always had a bit of an edge on us in this respect."

The parallax program with the powerful Thaw Refractor began in November, 1914. Jordan took part in getting plates for parallaxes until a year or two ago. He was a master of observing with telescopes and in making measures. It is a pleasure to read his clear, concise papers. He was a naturalist, and more concerned with making accurate observations of celestial objects than with making assumptions and basing speculations upon them.

It is fairly certain that Jordan never said a really unkind thing about anybody in all his life. The ordinary, ofttimes unfriendly, gossip which unfortunately so generally accompanies social intercourse would leave him standing by silently. In spite of his keenness of mind and sensitiveness of spirit he was one of the most thoroughly adjusted men I have ever known. And let no one deprecate these characteristics. Jordan was familiar with pain, sorrow, disappointment, and even injustice. By some inscrutable inner spring of power he always remained kindly, direct, genuine, sincere, and calm, no matter what happened. The fact that he was unobtrusively and sincerely religious may have had something to do with it. A letter from his pastor, the Reverend Maxwell Cornelius of the Watson Presbyterian Church in Pittsburgh, relates many facts of his churchly and religious life. Dr. Jordan and Mrs. Jordan joined the church on January 16, 1910. He served as organist, trustee, elder, treasurer, and teacher of Bible classes, and upon almost every committee having to do with the welfare of the local church as well as the wider work of his denomination.

During one of my visits to Pittsburgh Jordan took me to the nearby church and seated me upon one end of the long organ bench while he himself played the magnificent chorals, chants, and organ concertos of the ages for an unforgettable hour.

Throughout his life Jordan was in vigorous, radiant health. In college he was active in swimming, track, baseball, tennis. Later he took up golf. His son, John William, in a recent letter writes about him, "—he could rarely pass up a good river or lake without pausing for a swim, generally on the basis that the rest of us would enjoy the water. About twenty four years ago he started me diving by pushing me off a log into the Muskingum River; last summer he covered several acres of Lake Chautauqua with me and beat me all hollow at diving. How many men of the vintage of 1865 can you name who will yet delight in a six-foot springboard on a chilly lake?"

Since 1932 Jordan was elected each year as treasurer of the American Astronomical Society. With Mrs. Jordan he took the initiative in securing a planetarium for Pittsburgh in 1931. In October of 1939 they witnessed the dedication of the Buhl Planetarium and Institute of Popular Science. Both of them gave freely of their energies to encourage anyone who wanted to learn about the heavens, and in July, 1940, they participated in the Second Annual Convention of Amateur Astronomers.

Dr. Jordan was a member of The American Association for the Advancement of Science, the American Astronomical Society, the International Astronomical Union, Phi Beta Kappa, Sigma Xi (charter member of the Pittsburgh chapter), Pittsburgh Physical Society, Amateur Astronomers Association, Academy of Arts and Sciences, and other local organizations with social or scientific objectives.

Miss Esther Doody of the Allegheny Observatory staff appropriately

closes her article in *Sky* for April, 1941, as follows: "Students, teachers, administrators, colleagues and associates filled the Heinz Chapel of the University of Pittsburgh on the afternoon of February 21, 1941, to pay tribute to the memory of their friends, Dr. Frank C. Jordan and Mrs. Harriet C. Roy Jordan, who were so graciously associated in life that in death they were not parted."

DEARBORN OBSERVATORY, EVANSTON, ILLINOIS, APRIL 18, 1941.

A Trip Inside the Stars*

By THEODORE EUGENE STERNE

As one looks out of one's window, one sees—if it is day—a landscape illuminated by the sun. If it is night, one may see the landscape illuminated by the moon. But since, as we know, moonlight is but reflected sunlight, the light in both cases orginates in the sun. Curious people have speculated since early times on the nature of sunlight and on the nature of the sun from which it comes. Nowadays, we know that the sun is but one of many suns. All the stars are suns, and our particular sun is merely the star that happens to be closest to us. It is impossible to inquire into the nature of the sun without at the same time inquiring into the nature of the stars.

An inquiry into the nature of objects as remote and, at first sight, as inaccessible as the stars, is apt to impress the laymen as a rather hopeless one. Except for the sun, all the stars are so remote that they appear even in the largest telescopes merely as points of light; and even the sun, although it can easily be seen at sunset or through smoked glasses to have a visible size, shows us only its outside. Most of the matter within the sun remains veiled from human observation by the glowing opaque surface which is all that we can see. But like most complicated tasks that appear very difficult when faced for the first time in their entirety, it is possible to consider the problem part by part, adding bit by bit to the information at hand, until eventually one will see, I hope, that without any very rash or daring assumptions a good deal can still be said about the nature of stars.

To begin with, the first important and relevant information for our inquiry into the nature of stars concerns the masses of the stars. The mass of a body is the quantity of matter in it. We determine the masses of most things, on earth, by weighing them in pounds or grams. But the weight of a body, technically, is the force with which the earth attracts it; and the weight of a body is not a good measure of the quantity of matter that it contains unless the body is on the surface of the earth. Scientists therefore distinguish between the weight of a body and the

*A talk broadcast over Radio Station WRUL on January 25, 1941, in a series of astronomical broadcasts by members of the Harvard College Observatory staff.

mass of a body; we speak of the weight of a flat-iron as being so many pounds (or grams) for ordinary purposes, but for scientific purposes we speak of the mass of the flat-iron as being so many pounds, or grams. The mass of a given body does not depend upon where it is, and we can perfectly well speak of the mass of the earth as a whole, or of the mass of the sun, or of any other star. By the mass of any body we refer to the quantity of matter that it contains.

The mass of the sun was really determined for the first time when Cavendish, more than a century ago, measured in a physical laboratory the force with which two known masses attracted each other when they were a known distance apart. It had been known since the time of Newton that two bodies attracted each other with a force that was proportional to the product of the masses of the two bodies, and that the force diminished with increasing distance in accordance with the law of the inverse square. If one doubled the distance, the force was divided by four; if one trebled the distance, the force was divided by nine. But in Newton's time, the actual amount of the force, called gravitation, between two masses of one pound each, one foot apart, was not known. Cavendish measured the amount of the force of gravitation between two known masses, a known distance apart. From this result, since the weight of a mass of one pound on the earth's surface was known to be one pound, and since the distance of the earth's surface from the earth's center was known, it was possible to obtain the mass of the earth. In a similar manner, it was possible to obtain the mass of the sun. For the earth was known to be revolving about the sun, and the force required to hold the earth to its orbit around the sun must be due to the gravitational attraction of the sun for the earth. The distance to the sun had been measured, and the time spent in one revolution—the year—was known, and thus the force required was known. Cavendish's experiment enabled one immediately to compute how massive the sun had to be in order to supply just this amount of force, and the result, which has since then been slightly improved, is very nearly equal to the number of grams represented by 2 times 1 followed by thirty-three zeros.

I have gone into the manner of determining the mass of the sun rather carefully, for it is typical of the methods by which men have been able to obtain information about the nature of stars. It will be noticed that the mass of the sun is a property that relates to the whole of the sun, even its interior, which is hidden from direct observation. Yet we can find the sun's mass by making use of a law—the law of gravitation—obtained from the science of physics, a law confirmed alike in the laboratory and in the sky, and believed to be universal. The mass of the sun is found from our knowledge of this physical law, and from the sun's known gravitational attraction upon the earth.

The masses of a considerable number of other stars have been determined from a study of their gravitational effects upon each other, in the case of stars which occur in pairs that revolve around each other.

The gravitational effect of a pair of stars, revolving around each other, upon the earth is too small to allow their masses to be determined by exactly the same method as that which is so successful for determining the mass of the sun. Yet their effects upon each other are large and lead to a knowledge of their masses. Most of the stars whose masses have been measured are found to be between a tenth and fifty times as massive as our sun. A few stars are known to be more massive than that, but not many.

The size of the sun is readily determined from a knowledge of its apparent diameter—about one-half a degree—and its distance. In this case the law that is used is merely a law of geometry. The radius of the sun is about 700,000 kilometers. Other stars are as a rule too far away to have their diameters measured by geometry alone, and their sizes are found by measuring the amount of light received from them at the surface of the earth. The temperature of a star's surface can be found from the quality of its light, and the laws of radiation are sufficiently well known from physics to enable one, knowing the temperature of a star's surface, to compute how much light is given out by each square inch of the star's surface in one second. The star's distance is found by geometery, and then a knowledge of the light received at the earth, along with a knowledge of the light emitted by a unit area of the star, allows one to find the star's size.

The candle-power of a star, which astronomers call its "luminosity," is computed from its distance, and from the known amount of light that reaches the earth. Luminosities are usually given in the form of so many ergs per second, the erg being a unit of energy. The luminosity of the sun in ergs per second is about 5.6 times 1 followed by 33 zeros. This in watts is about the same as 5.6 times 1 followed by 26 zeros, or about three ten-millionths of a watt per second from each gram of matter inside the sun.

We have seen how one can find the masses, sizes, and luminosities of stars. One does it by making use not only of astronomical observations but also of certain laws such as the law of gravity and the laws of radiation. These laws are obtained from physical experiments carried out in physical laboratories, and from physical theory. We believe in the uniformity of nature, that is to say, that the laws of nature, are universally valid. For example, the law of gravitation is a law that has been verified by laboratory experiments, and no one hesitates to apply it to celestial bodies. As a matter of fact, the law of gravitation is perhaps unique among physical laws in actually having been verified for celestial bodies. As a rule, the other laws of physics deal with things of such a nature, like pressures and temperatures, as can be directly measured only in physical laboratories. Thus most of the laws of physics, unlike the law of gravitation, can have no direct verification from astronomical observation. Yet scientists are agreed in thinking that a gram of iron, at a certain temperature and pressure, would behave in the same way,

and have the same properties, if it were in the sun as it would under the same conditions on the earth. That is an example of what is meant by the principle of the "uniformity of nature".

To penetrate their outer surfaces, which hide the interiors of stars from direct observation, we continue to make use of the laws of physics, as those laws relate to the properties of radiation and of matter. The problem of penetrating to the interior is one of applying the laws correctly to our data, and the data are the observed masses, luminosities, and sizes. In a sense, we have already penetrated the surface, for the mass of a star, as we have seen, is a property that relates to its whole interior.

We have mentioned that the temperature of the surface of a star can be determined from the quality of the star's light. The lowest temperature yet known for the surface of any star is about 1000°C—approximately the melting temperature of cast iron. The highest temperature yet known for the surface of a star is some tens of thousands of degrees—far hotter than any terrestrial furnaces, and even hotter than the electric arc. One of the laws of physics states that heat flows from higher towards lower temperatures. If one end of a bar is heated, and the other is cooled by being immersed in ice, heat flows along the bar from the hot end to the cold end. The stars are constantly losing heat by radiating from their outer surfaces. If it were not for this radiation we would not be able to see the stars. This heat must obviously come from inside, and thus there must be a flow of heat outwards in a star, and by the law that has been mentioned it follows that the temperature inside of a star must increase from the surface toward the center. Hot as the outside of a star is, the inside must be much hotter. This has the immediate consequence that stars cannot be composed of solid matter.

From the quality of the light received from a star, scientists are able to determine what elementary chemical substances are present in a star's outer layers; so far many of the substances that are present on the earth have been found in the stars, but no substances have been found in the stars that are not present on the earth. This indicates that the stars are composed of the same fundamental chemical substances—called the chemical "elements"—that are familiar to us on the earth. Now laboratory experiments have shown that sufficiently high temperature will cause each chemical element to become a gas. Even carbon can be rendered gaseous. Moreover, it is found that, for sufficiently high temperatures, no amount of pressure can liquify or solidify the gaseous chemical element. "Pressure" is a technical term, that means the force per unit area—for instance, so many tons' weight per square inch. The temperature, above which no amount of pressure can solidify a substance, is called its "critical temperature", and since the critical temperatures of all known substances are low compared with the surface temperatures of most stars, and since they are almost certainly far lower than the temperatures inside of all stars, it follows that the stars are

composed of gas. Their surfaces are observed to be gaseous; their interiors are known to be gaseous because of the laws of physics.

We have now gone inside of the stars for some distance, and we have kept fairly well together. But from now on the way becomes, if not difficult, at least complicated. I shall not try to show you complete details of the remainder of the journey. I can show you, however, the general character of it, in order that you may be able to understand at least in part how the rest of the journey is accomplished.

We have introduced the notion of pressure—of the amount of force per unit of area. Another notion is essential to further progress—it is that of density. By density we mean the amount of mass in a unit of volume, such as so many grams per cubic centimeter, or so many tons per cubic foot. For any gas, there is a definite relation between its pressure, its density, and its temperature. In general, increasing the density increases the pressure, and increasing the temperature increases the pressure. The exact nature of the relationship has been determined by laboratory experiments that cover the whole range of temperatures and pressures obtainable by practical means on the earth, and very careful considerations, based upon our knowledge of the structure of matter, have shown that the same laws should hold under all circumstances provided that the temperature is sufficiently high in comparison with the density. When the temperature is not sufficiently high in comparison with the density, the laws take a different form; but the new form is generally believed to be known. It turns out that in ordinary stars the ordinary gas laws hold because the temperature is sufficiently high in comparison with the density; but that in a few extraordinary stars of unusually high density, but low temperature, the modified gas laws must be used. However, we are getting ahead of ourselves.

We have introduced the law relating the pressure of a gas to its density and to its temperature. We may call the pressure of the gas the gas pressure. In addition to gas pressure, the total pressure in any gas contains a part—small but measurable under laboratory conditions, and more and more important at higher and higher temperatures—a part called the radiation pressure. Radiation, of which visible light is a special sort, exerts pressure. The amount of pressure exerted by radiation is known, and depends only on the temperature. By adding radiation pressure to the gas pressure one obtains the total pressure. The total pressure in a gas increases with increasing temperature, and with increasing density.

Let us imagine that we could know the temperature, and the density, at a certain point inside of a star. Whatever the value of the pressure may be, it must be of course just the amount that is needed to support the overlying material against the attraction of the rest of the star. Each layer in the star is pulled down upon the lower layers by the force of gravity, and the force of gravity at any point depends upon the distance from the center and upon the mass of material between the point and the

center. Let us then consider what the pressure must be at a different point, somewhat closer to the center. The pressure at the second point must exceed the pressure at the first point by the force with which the intervening matter is attracted, and this force depends upon the density and thickness of the layer between the two points, and also upon the distance from the center, and also upon the mass interior to the inner point. This circumstance, combined with a knowledge of the relation between pressure, density, and temperature, would enable one to compute the density at all points inside a star if only the temperature at each point were known. At the outset, we do not know the temperature at each point; we merely know the temperature at the surface. But as we have seen, heat flows from higher towards lower temperatures, and the rate at which the heat flows is known from physics to be determined by the diminution in temperature in the direction in which the heat is flowing. If a column of gas is hotter at one end than at the other, heat flows from the hot end towards the cold end at a rate that is proportional to the difference between the temperatures of the two ends. The rate is also dependent upon a property of the gas called its "conductivity". By the conductivity is meant the number of calories of heat flowing across a unit area in one second, when the temperature drops one degree in the course of a centimeter's distance. This is a complicated definition, which it is not necessary for you to remember. The point is that the conductivity, and the rate of fall of temperature per unit of distance, determine the flow of heat; and that the conductivity fortunately is known to obey certain laws, which allow it to be computed once the temperature and density are known, in much the same way as one can compute the pressure from a knowledge of the temperature and density.

The law of conductivity supplies just the needed information and allows a mathematician to compute what the temperature and density must be at each point in a star's interior, provided that he knows the mass of the star and its radius and the chemical materials which compose it. Further, the luminosity of the star can then be computed.

The process that has been so briefly described to you has been applied to many stars having known sizes, masses, and luminosities. It was mentioned that the computed luminosity depended upon the size, mass, and chemical composition. Unless the chemical composition is right, the mathematician will compute a luminosity that does not agree with the correct, observed, luminosity. A discrepancy here indicates to him that he has assumed an incorrect composition, and in that case he performs his computations anew with the same mass and size, but with a different assumed composition. He continues to repeat his computations until he comes out with the correct luminosity, and then he stops, satisfied with his work.

It is found in this way, for example, that at the center of the sun the density is about 76 times that of water, while the temperature there is about 20 million degrees centigrade. The composition of most of the mat-

ter in the sun is one-third hydrogen. For another star, Sirius, the central temperature is found to be about twenty-four million degrees, and the central density about 40 times that of water. For both stars, the density is very much less in their outer parts than at their centers. Sirius, too, appears to be about one-third hydrogen.

I wish that I could tell you more about the interiors of these and of other stars—about the processes that must, according to physics, be going on under these conditions of extraordinarily high temperature. I should also like to be able to tell you about stars of quite a different sort, where the densities are very high—over fifty thousand times the density of water—and where the temperatures are lower than in the sun, so that one is forced to use the modification of the laws of gases, that I mentioned briefly once before. But there is no time for this, and if I have been able to show you how men have been able to find out something about the inside of the stars, I shall be satisfied with that.

HARVARD COLLEGE OBSERVATORY.

Dreamer to a Realist

I said wind is the breath of the stars,
You said no.
I cried, I love trees because they point to God.
You said, they just grow so.
The sun, I mused, is a wise old man,
You gave me a cold smile.
Clouds must be beds for angels, I said,
You laughed for a long while.

Tell me, what is it like to be you?
You have no dreams that cannot be true.

CABOT BARBER (Age 14).

Asteroid Names

By HUGH S. RICE

The subjoined alphabetical list embodies the names of all of the minor planets that have received names. There are 1410 names in the list. These asteroids are sufficiently well known to have their elements and ephemerides computed at the asteroid headquarters, the Coppernicus Institut at Dahlem, Germany. (Besides these there are a relatively few other planets with known elements; but they have not been given names, having only the provisional or temporary numbers assigned, up to the present time.)

Since 1931, the official method of designating an asteroid has been to use the number of the planet, followed by the name, without comma between, and with no parentheses or other marks surrounding the number. Inasmuch as this system is now exclusively in use at the Coppernicus Institut, we are following it here.

The magnitude column gives the average stellar magnitude of the asteroid at opposition with the sun.

The correct spelling of each planet is given in this list. Many of the names are in languages other than English, and the spelling and pronunciation as in the original must of course be used. Everything possible has been done to make the list correct. It is up-to-date as of the date at the end of the paper. As new names are slowly added from time to time, it is proposed to add such, together with any possible corrections to our list, in future numbers of "Asteroid Notes" in this magazine.

It is hoped that the list here given, arranged alphabetically as to names, will be found useful as a reference list by investigators concerned with asteroid observations.

Planet	*Mag.*	*Planet*	*Mag.*	*Planet*	*Mag.*
677 Aaltje	12.9	143 Adria	12.4	645 Agrippina	13.5
864 Aase	14.1	820 Adriana	13.2	744 Aguntina	13.6
456 Abnoba	12.9	91 Aegina	10.8	950 Ahrensa	13.2
151 Abundantia	11.9	96 Aegle	11.4	861 Aida	12.9
829 Academia	13.1	159 Aemilia	12.3	978 Aidamina	13.6
1150 Achaia	15.1	1155 Aënna	14.2	1404 Ajax	15.0
588 Achilles	14.2	396 Aeolia	13.2	738 Alagasta	13.4
523 Ada	12.8	369 Aëria	12.7	702 Alauda	12.0
330 Adalberta	13.5	1027 Aesculapia	14.8	719 Albert	17.6
525 Adelaide	13.8	446 Aeternitas	11.4	1290 Albertine	14.1
812 Adele	13.9	132 Aethra	11.5	465 Alekto	13.5
647 Adelgunde	13.5	1064 Aethusa	13.7	418 Alemannia	12.6
276 Adelheid	11.8	1142 Aetolia	13.6	259 Aletheia	12.1
229 Adelinda	13.5	1187 Afra	14.8	1194 Aletta	13.3
145 Adeona	11.3	1193 Africa	14.3	54 Alexandra	10.9
398 Admete	13.7	911 Agamemnon	13.6	1375 Alfreda	13.7
608 Adolfine	14.1	228 Agathe	14.5	1213 Algeria	14.6
.... Adonis	19	47 Aglaja	11.2	929 Algunde	13.6
268 Adorea	12.5	641 Agnes	14.5	291 Alice	13.6
239 Adrastea	14.0	847 Agnia	13.1	887 Alinda	17.1

Planet	*Mag.*	*Planet*	*Mag.*	*Planet*	*Mag.*
266 Aline	11.7	1031 Arctica	13.0	597 Bandusia	12.8
124 Alkeste	10.3	394 Arduina	12.8	298 Baptistina	13.5
82 Alkmene	11.2	737 Arequipa	11.2	234 Barbara	11.7
457 Alleghenia	15.1	197 Arete	12.7	945 Barcelona	13.2
390 Alma	13.2	95 Arethusa	11.3	819 Barnardiana	13.4
925 Alphonsina	11.4	469 Argentina	12.7	441 Bathilde	12.5
971 Alsatia	13.0	43 Ariadne	10.0	592 Bathseba	12.8
955 Alstede	14.2	1225 Ariane	13.9	172 Baucis	10.4
119 Althaea	10.6	1395 Aribeda	15.0	813 Baumeia	13.1
850 Altona	13.0	793 Arizona	12.5	301 Bavaria	12.7
1169 Alwine	15.0	780 Armenia	12.7	656 Beagle	13.6
650 Amalasuntha	14.7	514 Armida	12.4	1043 Beate	13.5
284 Amalia	12.9	774 Armor	12.5	83 Beatrix	11.3
113 Amalthea	11.0	959 Arne	14.2	1349 Bechuana	13.8
725 Amanda	13.5	1100 Arnica	14.2	943 Begonia	13.7
1085 Amaryllis	13.6	1018 Arnolda	12.4	1052 Belgica	12.9
1035 Amata	14.2	1304 Arosa	13.1	178 Belisana	12.0
1042 Amazone	13.3	404 Arsinoë	13.0	1074 Beljawskya	13.6
193 Ambrosia	12.9	105 Artemis	11.1	695 Bella	11.2
986 Amelia	13.7	214 Aschera	12.1	28 Bellona	10.1
916 America	13.4	67 Asia	11.2	1004 Belopolskya	13.5
516 Amherstia	11.0	1216 Askania	14.1	734 Benda	13.4
367 Amicitia	12.5	962 Aslög	14.3	976 Benjamina	13.3
871 Amneris	14.4	409 Aspasia	10.7	863 Benkoela	12.9
1221 Amor	18	958 Asplinda	14.3	776 Berbericia	11.0
198 Ampella	11.1	246 Asporina	11.7	653 Berenike	12.9
29 Amphitrite	9.0	1041 Asta	13.1	716 Berkeley	13.4
1065 Amundsenia	15.0	672 Astarte	13.3	1313 Berna	14.4
980 Anacostia	11.0	1218 Aster	15.1	629 Bernardina	13.8
270 Anahita	11.0	658 Asteria	13.6	422 Berolina	13.4
824 Anastasia	13.0	233 Asterope	11.3	154 Bertha	11.2
1173 Anchises	14.6	5 Astraea	9.9	420 Bertholda	12.3
1296 Andrée	14.0	1128 Astrid	13.1	937 Bethgea	14.2
175 Andromache	12.3	1154 Astronomia	14.2	250 Bettina	11.5
1172 Äneas	14.4	152 Atala	12.2	218 Bianca	11.4
965 Angelica	14.9	36 Atalante	12.0	1146 Biarmia	13.4
64 Angelina	10.5	1139 Atami	14.1	585 Bilkis	12.7
791 Ani	13.7	111 Ate	11.3	960 Birgit	14.2
1016 Anitra	13.5	515 Athalia	14.0	998 Bodea	14.4
265 Anna	13.8	230 Athamantis	10.3	371 Bohemia	11.8
910 Anneliese	13.1	730 Athanasia	14.7	720 Bohlinia	13.0
817 Annika	13.4	881 Athene	14.8	1141 Bohmia	14.8
129 Antigone	10.3	161 Athor	11.0	712 Boliviana	11.5
651 Antikleia	13.5	1198 Atlantis	16.8	1441 Bolyai	15.4
90 Antiope	11.6	810 Atossa	14.4	767 Bondia	13.8
272 Antonia	13.6	273 Atropos	11.6	361 Bononia	13.3
1294 Antwerpia	14.0	1138 Attica	14.4	741 Botolphia	13.0
1388 Aphrodite	14.0	254 Augusta	13.4	859 Bouzaréah	12.8
.... Apollo	17	700 Auravictrix	13.1	1342 Brabantia	14.0
358 Apollonia	12.5	419 Aurelia	11.1	640 Brambilla	13.0
988 Appella	14.8	1231 Auricula	14.1	1168 Brandia	14.5
1063 Aquilegia	12.9	94 Aurora	11.3	606 Brangäne	12.9
387 Aquitania	10.9	63 Ausonia	9.9	293 Brasilia	12.9
849 Ara	11.6	136 Austria	11.2	1411 Brauna	14.0
841 Arabella	13.2	1056 Azalea	13.4	786 Bredichina	13.0
1157 Arabia	13.8	856 Backlunda	13.2	761 Brendelia	13.7
1087 Arabis	13.4	333 Badenia	12.7	1211 Bressole	14.6
407 Arachne	11.9	1280 Baillauda	13.9	450 Brigitta	13.2
1005 Arago	13.6	770 Bali	13.0	655 Briseis	12.6
973 Aralia	13.5	324 Bamberga	9.9	1071 Brita	13.4
1020 Arcadia	14.1	1286 Banachiewicza	13.7	1219 Britta	14.0

Planet	*Mag.*	*Planet*	*Mag.*	*Planet*	*Mag.*
521 Brixia	12.1	311 Claudia	13.0	423 Diotima	11.2
1315 Bronislawa	13.5	1101 Clematis	14.6	1319 Disa	13.8
455 Bruchsalia	11.6	252 Clementina	13.0	382 Dodona	12.1
323 Brucia	12.1	935 Clivia	14.4	1277 Dolores	14.3
290 Bruna	13.9	661 Cloelia	12.7	1398 Donnera	15.4
123 Brunhild	11.8	282 Clorinde	13.3	668 Dora	15.0
901 Brunsia	13.5	237 Coelestina	12.8	48 Doris	10.9
908 Buda	13.3	972 Cohnia	13.3	339 Dorothea	12.8
338 Budrosa	12.1	1135 Colchis	13.6	620 Drakonia	13.6
384 Burdigala	11.7	327 Columbia	13.0	263 Dresda	13.3
374 Burgundia	11.7	489 Comacina	12.5	400 Ducrosa	14.5
834 Burnhamia	12.7	58 Concordia	11.6	564 Dudu	13.7
199 Byblis	12.4	315 Constantia	14.0	571 Dulcinea	13.8
297 Caecilia	13.3	815 Coppelia	13.6	1338 Duponta	14.8
952 Caia	13.4	1322 Coppernicus	15.1	200 Dynamene	11.3
341 California	13.1	504 Cora	12.7	1241 Dysona	12.9
1245 Calvinia	13.1	365 Corduba	12.2	1205 Ebella	16.1
957 Camelia	13.2	425 Cornelia	13.1	60 Echo	11.1
107 Camilla	11.2	1232 Cortusa	13.8	413 Edburga	12.2
377 Campania	11.5	1442 Corvina	14.2	673 Edda	13.0
1077 Campanula	14.7	915 Cosette	13.9	742 Edisona	12.5
1120 Cannonia	13.6	644 Cosima	13.1	517 Edith	13.1
740 Cantabia	12.6	486 Cremona	13.5	1341 Edmée	13.7
479 Caprera	13.0	660 Crescentia	10.6	445 Edna	12.6
1391 Carelia	15.8	1140 Crimea	13.2	340 Eduarda	12.9
491 Carina	12.5	589 Croatia	12.7	1046 Edwin	13.9
360 Carlova	11.9	1220 Crocus	14.9	13 Egeria	9.7
558 Carmen	12.2	763 Cupido	14.6	442 Eichsfeldia	12.1
671 Carnegia	13.1	403 Cyane	12.0	694 Ekard	12.4
235 Carolina	12.2	65 Cybele	11.0	858 El Djezaïr	13.6
1116 Catriona	13.0	1106 Cydonia	14.2	130 Elektra	10.6
1344 Caubeta	14.5	133 Cyrene	11.3	354 Eleonora	10.0
505 Cava	12.0	61 Danaë	11.0	567 Eleutheria	13.1
1252 Celestia	13.5	1381 Danubia	14.3	618 Elfriede	12.4
186 Celuta	11.4	1419 Danzig	13.8	1329 Eliane	12.9
1240 Centenaria	13.7	41 Daphne	10.5	956 Elisa	14.6
513 Centesima	12.3	1270 Datura	15.0	412 Elisabetha	11.9
807 Ceraskia	13.5	511 Davida	9.6	435 Ella	12.1
1 Ceres	7.4	1037 Davidweilla	15.1	616 Elly	12.7
1333 Cevenola	14.7	541 Deborah	12.9	59 Elpis	10.9
1246 Chaka	14.7	1295 Deflotte	14.8	182 Elsa	11.0
313 Chaldaea	10.3	1244 Deira	13.3	277 Elvira	13.1
627 Charis	13.1	157 Dejanira	13.7	1234 Elyna	14.3
543 Charlotte	12.7	184 Dejopeja	12.4	576 Emanuela	12.7
388 Charybdis	11.7	395 Delia	13.0	481 Emita	11.6
568 Cheruskia	12.3	560 Delila	13.4	283 Emma	11.8
334 Chicago	12.0	1274 Delportia	13.5	342 Endymion	12.8
623 Chimaera	12.8	349 Dembowska	9.8	221 Eos	11.3
1125 China	16.5	1108 Demeter	14.5	802 Epyaxa	13.7
402 Chloë	10.7	1335 Demoulina	15.2	62 Erato	12.3
410 Chloris	11.9	667 Denise	13.4	894 Erda	13.5
938 Chlosinde	14.6	1339 Désagneauxa	13.7	1254 Erfordia	13.8
1015 Christa	13.0	666 Desdemona	13.6	1402 Eri	15.8
628 Christine	12.2	344 Desiderata	11.7	718 Erida	12.8
202 Chryseïs	10.7	337 Devosa	11.4	163 Erigone	11.5
637 Chrysothemis	14.0	1328 Devota	14.0	636 Erika	12.4
1275 Cimbria	13.7	78 Diana	10.6	462 Eriphyla	13.5
1307 Cimmeria	13.5	209 Dido	11.5	705 Erminia	12.1
34 Circe	11.5	99 Dike	13.7	406 Erna	13.5
642 Clara	13.5	1437 Diomedes	14.2	698 Ernestina	13.8
302 Clarissa	13.9	106 Dione	11.3	433 Eros	10.7

Planet	*Mag.*	*Planet*	*Mag.*	*Planet*	*Mag.*
889 Erynia	13.0	1250 Galanthus	15.3	682 Hagar	14.8
622 Esther	12.8	74 Galatea	11.8	368 Haidea	13.5
331 Etheridgea	12.5	427 Galene	12.8	1098 Hakone	13.8
1119 Euboea	13.6	697 Galilea	12.5	518 Halawe	13.4
181 Eucharis	11.5	148 Gallia	11.0	1024 Hale	15.4
217 Eudora	13.1	1036 Ganymed	12.5	1308 Halleria	14.1
45 Eugenia	10.7	1435 Garlena	15.9	449 Hamburga	12.0
743 Eugenisis	13.0	180 Garumna	13.3	452 Hamiltonia	16.7
247 Eukrate	11.0	951 Gaspra	13.5	723 Hammonia	13.3
495 Eulalia	12.5	1001 Gaussia	13.0	480 Hansa	11.5
185 Eunike	10.0	764 Gedania	13.2	1118 Hanskya	13.9
15 Eunomia	8.6	1267 Geertruida	14.2	724 Hapag	15.5
630 Euphemia	13.5	1272 Gefion	15.1	578 Happelia	12.0
31 Euphrosyne	11.0	1047 Geisha	14.2	1372 Haremari	14.7
52 Europa	10.3	1199 Geldonia	13.4	40 Harmonia	9.2
527 Euryanthe	12.5	1073 Gellivara	14.6	736 Harvard	12.3
75 Eurydike	11.6	1385 Gelria	13.4	362 Havnia	11.1
195 Eurykleia	12.6	1237 Geneviève	13.3	6 Hebe	8.5
79 Eurynome	10.5	680 Genoveva	13.2	108 Hecuba	11.7
27 Euterpe	9.7	485 Genua	11.4	207 Hedda	11.8
164 Eva	11.5	376 Geometria	11.8	1251 Hedera	13.9
503 Evelyn	12.3	359 Georgia	12.3	476 Hedwig	11.3
751 Faina	11.5	300 Geraldina	12.5	325 Heidelberga	12.4
408 Fama	13.4	1433 Geramtina	14.6	100 Hekate	11.9
821 Fanny	14.0	1227 Geranium	14.3	624 Hektor	13.2
1224 Fantasia	13.5	1337 Gerarda	14.3	949 Hel	13.8
866 Fatme	12.6	122 Gerda	11.5	699 Hela	14.5
1418 Fayeta	13.5	663 Gerlinde	13.0	101 Helena	10.7
294 Felicia	13.4	241 Germania	11.2	522 Helga	12.6
109 Felicitas	12.0	686 Gersuind	13.9	1075 Helina	14.0
1453 Fennia	14.8	1382 Gerti	14.1	895 Helio	13.0
1048 Feodosia	12.6	710 Gertrud	14.1	967 Helionape	14.0
72 Feronia	11.2	613 Ginevra	13.0	1370 Hella	15.2
524 Fidelio	12.4	352 Gisela	12.1	1273 Helma	15.1
37 Fides	10.4	492 Gismonda	13.1	801 Helwerthia	13.9
380 Fiducia	12.6	857 Glasenappia	13.2	225 Henrietta	12.7
1099 Figneria	15.0	288 Glauke	12.5	826 Henrika	13.3
795 Fini	12.6	316 Goberta	13.3	103 Hera	10.2
1021 Flammario	11.5	1226 Golia	14.3	880 Herba	14.9
8 Flora	8.9	1177 Gonnessia	13.4	1363 Herberta	14.2
321 Florentina	13.2	305 Gordonia	12.5	532 Herculina	9.8
1054 Forsytia	13.9	681 Gorgo	14.3	458 Hercynia	13.1
19 Fortuna	9.8	1346 Gotha	13.8	923 Herluga	14.1
1105 Fragaria	13.6	1188 Gothlandia	13.2	346 Hermentaria	11.5
1212 Francette	14.8	1049 Gotho	14.2	.... Hermes	18
982 Franklina	13.3	1159 Granada	14.5	685 Hermia	13.5
862 Franzia	12.8	424 Gratia	12.8	121 Hermione	11.2
520 Franziska	13.9	984 Gretia	12.9	546 Herodias	12.1
309 Fraternitas	12.7	1362 Griqua	14.4	206 Hersilia	12.0
1093 Freda	13.5	493 Griseldis	14.5	135 Hertha	10.5
678 Fredegundis	12.6	1058 Grubba	14.3	69 Hesperia	10.7
76 Freia	12.0	496 Gryphia	13.0	46 Hestia	10.6
722 Frieda	13.5	328 Gudrun	12.3	944 Hidalgo	17.1
538 Friederike	13.2	799 Gudula	12.8	996 Hilaritas	14.2
77 Frigga	11.1	891 Gunhild	13.3	153 Hilda	12.6
709 Fringilla	12.1	983 Gunila	13.1	684 Hildburg	13.5
1253 Frisia	15.6	657 Gunlöd	13.7	898 Hildegard	15.1
854 Frostia	14.0	961 Gunnie	13.8	928 Hildrun	13.1
609 Fulvia	12.8	777 Gutemberga	13.9	426 Hippo	11.5
355 Gabriella	13.1	806 Gyldenia	13.5	692 Hippodamia	13.3
1184 Gaea	13.6	444 Gyptis	11.2	706 Hirundo	13.9

Planet	*Mag.*	*Planet*	*Mag.*	*Planet*	*Mag.*
804 Hispania	11.2	918 Itha	13.8	191 Kolga	12.0
788 Hohensteina	12.6	1151 Ithaka	15.5	1445 Konkolya	14.5
872 Holda	13.3	497 Iva	13.5	940 Kordula	13.4
1132 Hollandia	13.0	1017 Jacqueline	13.7	158 Koronis	12.3
378 Holmia	12.6	383 Janina	13.3	867 Kovacia	14.0
236 Honoria	11.4	1110 Jaroslawa	13.7	548 Kressida	13.2
932 Hooveria	11.5	1281 Jeanne	13.6	800 Kressmannia	12.9
805 Hormuthia	12.9	526 Jena	13.1	488 Kreusa	11.5
260 Huberta	13.9	607 Jenny	12.6	242 Kriemhild	12.6
379 Huenna	12.6	1414 Jérôme	15.3	553 Kundry	13.7
434 Hungaria	11.8	549 Jessonda	13.5	936 Kunigunde	14.0
430 Hybris	13.2	544 Jetta	12.6	1289 Kutaissi	13.5
10 Hygiea	9.5	726 Joëlla	13.4	669 Kypria	13.7
238 Hypatia	11.7	127 Johanna	10.5	570 Kythera	12.7
1309 Hyperborea	13.9	899 Jokaste	13.6	336 Lacadiera	11.8
587 Hypsipyle	14.3	836 Jole	14.3	120 Lachesis	11.7
98 Ianthe	12.7	1423 Jose	14.8	208 Lacrimosa	12.1
286 Iclea	13.2	649 Josefa	15.1	39 Laetitia	9.5
243 Ida	13.3	303 Josephina	12.0	1006 Lagrangea	15.1
963 Iduberga	14.3	921 Jovita	13.4	1412 Lagrula	13.9
176 Iduna	12.1	652 Jubilatrix	13.3	822 Lalage	13.4
1160 Illyria	14.4	948 Jucunda	13.8	187 Lamberta	11.4
385 Ilmatar	10.3	664 Judith	14.2	248 Lameia	13.0
1182 Ilona	13.3	139 Juewa	10.9	393 Lampetia	11.0
249 Ilse	13.6	1248 Jugurtha	13.0	683 Lanzia	12.4
919 Ilsebill	13.8	89 Julia	10.1	1011 Laodamia	15.9
979 Ilsewa	13.6	816 Juliana	13.7	507 Laodica	12.5
926 Imhilde	14.0	1285 Julietta	13.0	1008 La Paz	14.4
1320 Impala	14.2	3 Juno	8.7	1029 La Plata	13.7
1200 Imperatrix	14.0	269 Justitia	12.7	1162 Larissa	13.7
1165 Imprinetta	13.8	1183 Jutta	14.3	639 Latona	12.1
1325 Inanda	14.4	605 Juvisia	12.9	1284 Latvia	13.5
389 Industria	11.1	22 Kalliope	9.8	467 Laura	14.3
391 Ingeborg	13.2	204 Kallisto	12.0	162 Laurentia	12.3
1026 Ingrid	14.8	53 Kalypso	11.5	1401 Lavonne	13.1
561 Ingwelde	13.9	818 Kapteynia	13.0	38 Leda	11.4
848 Inna	14.1	832 Karin	13.4	1261 Legia	14.1
173 Ino	11.0	781 Kartvelia	13.1	691 Lehigh	12.8
704 Interamnia	10.3	1316 Kasan	15.5	789 Lena	14.1
85 Io	10.9	114 Kassandra	11.1	969 Leocadia	14.5
509 Iolanda	11.5	646 Kastalia	14.5	319 Leona	14.2
112 Iphigenia	11.5	320 Katharina	13.7	1378 Leonce	13.9
794 Irenaea	14.6	1113 Katja	13.3	728 Leonisis	14.3
14 Irene	9.7	1278 Kenya	14.2	696 Leonora	13.2
7 Iris	8.4	1134 Kepler	17.3	844 Leontina	12.8
177 Irma	12.4	842 Kerstin	13.7	893 Leopoldina	12.9
1178 Irmela	16.6	470 Kilia	12.9	1264 Letaba	12.9
591 Irmgard	13.5	1156 Kira	14.3	68 Leto	10.5
773 Irmintraud	12.4	216 Kleopatra	10.1	35 Leukothea	12.2
1485 Isa	14.5	84 Klio	11.3	1361 Leuschneria	14.2
210 Isabella	12.5	97 Klotho	10.6	954 Li	14.0
364 Isara	11.7	583 Klotilde	13.1	771 Libera	13.4
939 Isberga	13.8	1040 Klumpkea	14.2	125 Liberatrix	11.2
1271 Isergina	14.2	104 Klymene	12.2	264 Libussa	12.1
42 Isis	10.4	179 Klytaemnestra	11.5	1268 Libya	13.2
1409 Isko	13.5	73 Klytia	12.0	1107 Lictoria	12.7
190 Ismene	12.0	1384 Kniertje	14.3	356 Liguria	11.0
211 Isolda	11.5	1311 Knopfia	14.8	213 Lilaea	11.7
1374 Isora	15.1	1324 Knysna	13.9	1181 Lilith	14.1
183 Istria	12.6	1164 Kobolda	14.4	1092 Lilium	13.6
477 Italia	12.1	1233 Kobresia	13.6	756 Lilliana	13.9

Planet	*Mag.*	*Planet*	*Mag.*	*Planet*	*Mag.*
1003 Lilofee	13.3	1410 Margret	14.4	370 Modestia	12.8
1383 Limburgia	15.0	170 Maria	11.7	766 Moguntia	12.9
468 Lina	13.1	602 Marianna	12.1	638 Moira	13.5
1407 Lindelöf	15.0	1486 Marilyn	15.1	428 Monachia	13.5
828 Lindemannia	13.7	1202 Marina	14.9	833 Monica	14.4
974 Lioba	12.9	506 Marion	12.5	535 Montague	11.8
846 Lipperta	13.9	912 Maritima	11.9	797 Montana	12.5
414 Liriope	13.4	1010 Marlene	13.8	782 Montefiore	13.0
1062 Ljuba	13.3	746 Marlu	12.5	947 Monterosa	12.3
1066 Lobelia	14.8	1174 Marmara	14.9	1257 Móra	14.1
463 Lola	14.0	711 Marmulla	13.0	1210 Morosovia	13.5
117 Lomia	11.4	205 Martha	12.7	787 Moskva	12.8
1287 Lorcia	13.8	981 Martina	14.3	993 Moultona	14.8
165 Loreley	11.1	20 Massalia	9.2	941 Murray	14.4
1114 Lorraine	12.7	760 Massinga	11.9	600 Musa	13.0
1326 Losaka	15.1	454 Mathesis	11.6	966 Muschi	12.7
429 Lotis	12.6	253 Mathilde	13.4	381 Myrrha	12.4
868 Lova	12.7	883 Matterania	13.7	845 Naëma	13.1
1292 Luce	13.3	765 Mattiaca	15.1	1327 Namaqua	14.0
222 Lucia	12.9	745 Mauritia	13.6	1203 Nanna	14.6
1176 Lucidor	13.9	1217 Maximiliana	15.1	559 Nanon	12.3
146 Lucina	11.1	348 May	12.9	853 Nansenia	13.5
281 Lucretia	13.1	991 McDonalda	15.8	534 Nassovia	12.8
1158 Luda	13.7	873 Mechthild	14.1	1086 Nata	13.0
675 Ludmilla	11.2	212 Medea	12.2	448 Natalie	13.4
292 Ludovica	12.5	149 Medusa	12.9	1121 Natascha	14.0
1133 Lugduna	13.3	464 Megaira	12.2	811 Nauheima	13.6
599 Luisa	12.4	688 Melanie	13.5	192 Nausikaa	9.3
141 Lumen	11.4	56 Melete	11.3	903 Nealley	13.4
775 Lumière	13.7	137 Meliboea	11.8	1223 Neckar	14.1
1067 Lunaria	14.4	676 Melitta	12.5	1122 Neith	14.5
809 Lundia	13.6	869 Mellena	14.4	51 Nemausa	9.8
1334 Lundmarka	14.2	18 Melpomene	9.3	128 Nemesis	10.6
713 Luscinia	12.9	373 Melusina	12.8	289 Nenetta	13.0
21 Lutetia	10.1	1247 Memoria	14.2	431 Nephele	12.6
1303 Luthera	13.1	188 Menippe	13.0	287 Nephthys	10.7
110 Lydia	10.5	1078 Mentha	13.9	1318 Nerina	13.8
917 Lyka	13.6	536 Merapi	11.7	601 Nerthus	12.6
897 Lysistrata	13.7	1136 Mercedes	13.8	659 Nestor	14.4
1353 Maartje	13.5	1051 Merope	13.8	1129 Neujmina	13.4
510 Mabella	13.0	1299 Mertona	14.8	855 Newcombia	13.5
318 Magdalena	13.2	808 Merxia	13.1	662 Newtonia	13.3
1060 Magnolia	14.8	545 Messalina	12.2	843 Nicolaia	14.7
1459 Magnya	14.2	1050 Meta	15.1	1343 Nicole	14.2
66 Maja	12.2	792 Metcalfia	12.8	307 Nike	13.1
1321 Majuba	13.5	9 Metis	8.9	1185 Nikko	13.7
754 Malabar	12.8	1348 Michel	13.5	779 Nina	11.5
1415 Malautra	13.9	1045 Michela	15.8	357 Ninina	12.2
1179 Mally	16.1	1376 Michelle	14.5	71 Niobe	10.7
1072 Malva	14.0	878 Mildred	16.9	727 Nipponia	12.7
749 Malzovia	13.5	1127 Mimi	13.1	1298 Nocturna	13.8
758 Mancunia	11.3	1079 Mimosa	14.2	703 Noëmi	13.9
739 Mandeville	12.2	93 Minerva	10.8	1068 Nofretete	12.9
870 Manto	13.5	1458 Mineura	14.0	473 Nolli	13.3
565 Marbachia	12.9	594 Mireille	15.0	783 Nora	13.2
1300 Marcelle	14.2	102 Miriam	12.6	555 Norma	13.9
1332 Marconia	13.3	569 Misa	12.4	1256 Normannia	14.4
310 Margarita	13.5	1088 Mitaka	13.4	626 Notburga	11.4
735 Marghanna	12.4	1455 Mitchella	14.8	1206 Numerowia	14.6
1175 Margo	14.3	57 Mnemosyne	10.7	1368 Numidia	12.9
1434 Margot	13.6	733 Mocia	13.0	150 Nuwa	11.6

Planet	*Mag.*	*Planet*	*Mag.*	*Planet*	*Mag.*
1356 Nyanza	12.8	271 Penthesilea	12.8	762 Pulcova	11.7
875 Nymphe	13.8	1102 Pepita	13.0	1209 Pumma	14.3
44 Nysa	9.8	554 Peraga	10.8	632 Pyrrha	14.5
224 Oceana	11.7	399 Persephone	13.0	432 Pythia	11.3
475 Ocllo	13.5	975 Perseverantia	13.0	1297 Quadea	14.4
598 Octavia	12.0	482 Petrina	12.0	1239 Queteleta	14.6
1144 Oda	13.6	830 Petropolitana	12.0	755 Quintilla	13.3
1143 Odysseus	14.0	968 Petunia	13.3	674 Rachele	10.7
215 Oenone	12.7	174 Phaedra	11.6	1420 Radcliffe	14.3
1259 Ogyalla	14.1	322 Phaeo	12.3	1137 Raïssa	13.0
439 Ohio	12.7	296 Phaëtusa	13.3	708 Raphaela	13.2
1002 Olbersia	14.0	274 Philagoria	13.6	1148 Raraju	13.7
304 Olga	12.4	280 Philia	14.4	927 Ratisbona	13.1
835 Olivia	13.8	977 Philippa	13.2	572 Rebekka	12.9
582 Olympia	12.6	631 Philippina	12.3	573 Recha	13.2
1389 Onnie	14.0	196 Philomela	10.3	285 Regina	14.9
171 Ophelia	12.1	227 Philosophia	12.9	574 Reginhild	14.3
255 Oppavia	13.3	25 Phocaea	10.5	1117 Reginita	13.6
1195 Orangia	14.9	443 Photographica	12.5	1111 Reinmuthia	13.3
1080 Orchis	14.5	1291 Phryne	13.4	575 Renate	13.5
701 Oriola	13.1	189 Phthia	11.5	1416 Renauxa	13.9
350 Ornamenta	12.7	556 Phyllis	12.5	1204 Renzia	14.8
551 Ortrud	12.8	614 Pia	13.7	906 Repsolda	12.1
750 Oskar	13.8	1000 Piazzia	13.8	1081 Reseda	14.6
343 Ostara	13.5	1366 Piccolo	13.1	1371 Resi	14.9
1207 Ostenia	14.9	803 Picka	13.1	1096 Reunerta	12.8
1126 Otero	14.3	784 Pickeringia	13.1	528 Rezia	12.4
913 Otila	14.2	1392 Pierre	16.0	577 Rhea	13.0
670 Ottegebe	13.4	312 Pierretta	12.5	907 Rhoda	12.7
994 Otthild	13.0	648 Pippa	13.1	1197 Rhodesia	12.8
401 Ottilia	12.6	1082 Pirola	13.9	437 Rhodia	12.7
363 Padua	11.6	484 Pittsburghia	12.9	166 Rhodope	12.5
1061 Paeonia	14.7	1069 Planckia	13.2	879 Ricarda	13.9
1032 Pafuri	12.8	946 Poësia	13.8	1230 Riceia	15.7
953 Painleva	13.5	142 Polana	12.2	1214 Richilde	12.9
415 Palatia	11.6	1112 Polonia	13.5	1025 Riema	13.7
49 Pales	11.0	33 Polyhymnia	11.8	1180 Rita	14.2
914 Palisana	12.2	595 Polyxena	12.1	1145 Robelmonte	13.4
2 Pallas	8.0	308 Polyxo	11.0	1377 Roberbauxa	14.7
372 Palma	10.5	32 Pomona	10.6	335 Roberta	11.6
1243 Pamela	14.9	203 Pompeja	11.7	904 Rockefellia	13.5
539 Pamina	13.1	1305 Pongola	13.6	920 Rogeria	13.5
55 Pandora	10.8	757 Portlandia	12.6	1269 Rollandia	13.4
70 Panopaea	10.9	1131 Porzia	15.6	472 Roma	11.5
471 Papagena	10.1	1345 Potomac	14.1	942 Romilda	13.9
347 Pariana	12.0	547 Praxedis	12.7	223 Rosa	13.3
11 Parthenope	9.3	790 Pretoria	12.7	314 Rosalia	14.0
888 Parysatis	12.9	529 Preziosa	13.0	900 Rosalinde	14.3
451 Patientia	10.6	884 Priamus	14.0	540 Rosamunde	12.1
1347 Patria	13.4	1359 Prieska	13.2	985 Rosina	14.8
436 Patricia	12.9	970 Primula	14.9	1350 Rosselia	14.9
617 Patroclus	12.6	508 Princetonia	12.3	1440 Rostia	15.4
1314 Paula	14.7	997 Priska	14.7	615 Roswitha	12.6
278 Paulina	12.7	1192 Prisma	13.7	874 Rotraut	13.4
537 Pauly	13.1	902 Probitas	14.5	1413 Roucarie	14.3
1007 Pawlowia	14.1	194 Prokne	10.5	317 Roxane	12.2
1152 Pawona	13.4	26 Proserpina	10.5	353 Ruperto-Carola	14.2
679 Pax	10.9	147 Protogeneia	12.5	232 Russia	13.4
118 Peitho	10.8	474 Prudentia	13.0	1171 Rusthawelia	13.3
1190 Pelagia	14.2	261 Prymno	11.5	798 Ruth	12.9
201 Penelope	11.9	16 Psyche	9.6	1249 Rutherfordia	13.3

Planet	*Mag.*	*Planet*	*Mag.*	*Planet*	*Mag.*
1115 Sabauda	13.5	1331 Solvejg	14.6	405 Thia	11.0
665 Sabine	12.8	1293 Sonja	15.0	88 Thisbe	10.8
1364 Safara	14.3	1039 Sonneberga	13.5	1023 Thomana	14.0
1163 Saga	13.6	251 Sophia	13.6	299 Thora	14.5
1166 Sakuntala	14.1	134 Sophrosyne	11.1	279 Thule	13.8
562 Salome	12.9	731 Sorga	12.7	934 Thuringia	14.1
1083 Salvia	14.7	896 Sphinx	13.5	219 Thusnelda	11.2
1288 Santa	14.8	1091 Spiraea	14.8	115 Thyra	10.4
275 Sapientia	12.0	831 Stateira	13.9	753 Tiflis	13.3
80 Sappho	10.6	1147 Stavropolis	14.4	1229 Tilia	15.1
533 Sara	13.5	707 Stella	13.6	603 Timandra	13.9
1012 Sarema	14.3	220 Stephania	13.6	1222 Tina	14.8
796 Sarita	12.2	566 Stereoskopia	12.0	687 Tinette	14.8
461 Saskia	14.3	995 Sternberga	13.4	1400 Tirela	15.1
1228 Scabiosa	14.4	1386 Storeria	15.3	267 Tirza	14.0
460 Scania	13.9	1201 Strenua	14.2	466 Tisiphone	11.8
643 Scheherezade	13.9	1422 Strömgrenia	15.4	593 Titania	12.4
596 Scheila	12.0	1124 Stroobantia	14.3	732 Tjilaki	13.1
1255 Schilowa	14.4	768 Struveana	14.0	498 Tokio	11.2
922 Schlutia	14.6	964 Subamara	14.1	138 Tolosa	11.8
1235 Schorria	15.2	417 Suevia	12.7	1013 Tombecka	13.4
837 Schwarzschilda	13.5	752 Sulamitis	13.0	590 Tomyris	13.1
989 Schwassmannia	14.7	563 Suleika	11.1	1266 Tone	13.2
1265 Schweikarda	13.3	1090 Sumida	14.6	924 Toni	12.8
876 Scott	13.9	1424 Sundmania	14.8	715 Transvaalia	13.2
155 Scylla	13.5	542 Susanna	12.8	619 Triberga	12.1
1306 Scythia	13.4	933 Susi	14.6	1208 Troilus	14.8
892 Seeligeria	13.2	329 Svea	12.1	1408 Trusanda	14.4
580 Selene	13.7	992 Swasey	14.6	1038 Tuckia	14.5
500 Selinur	12.0	882 Swetlana	14.1	1323 Tugela	13.9
86 Semele	12.4	519 Sylvania	12.0	1095 Tulipa	13.1
584 Semiramis	11.5	87 Sylvia	11.9	1070 Tunica	14.7
1014 Semphyra	14.9	1104 Syringa	15.4	530 Turandot	12.4
550 Senta	11.9	721 Tabora	14.0	1186 Turnera	14.5
483 Seppina	12.5	1089 Tama	13.4	258 Tyche	11.1
1103 Sequoia	13.3	326 Tamara	11.1	1055 Tynka	13.1
838 Seraphina	13.1	1084 Tamariwa	13.3	1276 Ucclia	14.0
1123 Shapleya	13.7	772 Tanete	12.1	1279 Uganda	14.7
1196 Sheba	13.1	825 Tanina	13.0	909 Ulla	12.6
1094 Siberia	13.6	1109 Tata	13.7	885 Ulrike	13.7
168 Sibylla	11.6	769 Tatjana	12.8	714 Ulula	11.3
1258 Sicilia	14.3	581 Tauntonia	13.7	160 Una	11.8
579 Sidonia	11.5	512 Taurinensis	12.5	92 Undina	10.9
386 Siegena	10.5	814 Tauris	12.6	306 Unitas	10.7
552 Sigelinde	12.2	453 Tea	12.3	905 Universitas	12.6
459 Signe	13.7	604 Tekmessa	12.4	30 Urania	9.9
1493 Sigrid	14.1	1399 Teneriffa	15.4	167 Urda	13.0
502 Sigune	13.8	345 Tercidina	11.2	501 Urhixidur	13.0
257 Silesia	12.8	1189 Terentia	13.2	860 Ursina	12.8
1317 Silvretta	12.2	478 Tergeste	10.9	375 Ursula	11.0
748 Simeïsa	13.5	81 Terpsichore	11.8	634 Ute	13.1
1033 Simona	14.2	1044 Teutonia	13.9	1282 Utopia	15.6
1009 Sirene	17.7	1236 Thaïs	13.7	131 Vala	12.2
332 Siri	12.6	23 Thalia	10.5	839 Valborg	13.0
116 Sirona	10.7	586 Thekla	12.9	262 Valda	14.1
823 Sisigambis	13.7	24 Themis	10.8	447 Valentine	12.1
244 Sita	13.7	778 Theobalda	14.1	611 Valeria	12.3
1170 Siva	13.9	440 Theodora	13.1	610 Valeska	15.6
140 Siwa	11.4	295 Theresia	13.5	240 Vanadis	12.5
1130 Skuld	14.1	1161 Thessalia	15.0	1263 Varsavia	11.8
1262 Sniadeckia	13.4	17 Thetis	10.1	1312 Vassar	15.9

Planet	*Mag.*	*Planet*	*Mag.*	*Planet*	*Mag.*
416 Vaticana	11.5	635 Vundtia	12.6	690 Wratislavia	11.8
126 Velleda	11.5	1260 Walhalla	14.1	411 Xanthe	12.5
487 Venetia	11.8	1417 Walinskia	14.7	156 Xanthippe	11.3
499 Venusia	13.0	877 Walküre	12.9	625 Xenia	12.1
245 Vera	12.5	1153 Wallenbergia	13.8	990 Yerkes	15.8
490 Veritas	12.3	987 Wallia	14.0	351 Yrsa	12.2
612 Veronika	14.6	256 Walpurga	13.2	1340 Yvette	14.6
4 Vesta	6.5	890 Waltraut	13.5	1301 Yvonne	13.7
144 Vibilia	10.7	1057 Wanda	13.0	999 Zachia	14.3
1097 Vicia	15.0	886 Washingtonia	13.5	421 Zähringia	14.2
12 Victoria	9.7	729 Watsonia	12.9	1242 Zambesia	12.3
397 Vienna	12.2	1352 Wawel	13.9	1336 Zeelandia	13.9
1053 Vigdis	14.9	1438 Wendeline	15.2	851 Zeissia	13.5
1310 Villigera	13.6	621 Werdandi	13.9	169 Zelia	11.3
366 Vincentina	12.3	226 Weringia	13.0	633 Zelima	12.9
231 Vindobona	12.4	1302 Werra	14.3	654 Zelinda	11.1
759 Vinifera	13.8	930 Westphalia	13.5	840 Zenobia	13.0
1076 Viola	14.1	931 Whittemora	13.4	693 Zerbinetta	12.8
557 Violetta	13.7	392 Wilhelmina	12.2	531 Zerlina	14.0
50 Virginia	11.7	747 Winchester	11.0	438 Zeuxo	11.8
494 Virtus	12.3	717 Wisibada	14.0	689 Zita	14.2
1439 Vogtia	14.5	852 Wladilena	12.7	865 Zubaida	14.1
1380 Volodia	15.3	827 Wolfiana	14.8	785 Zwetana	12.6

HAYDEN PLANETARIUM, AMERICAN MUSEUM OF NATURAL HISTORY,
NEW YORK CITY, APRIL, 1941.

Pseudo-Science and Revelation

By N. T. BOBROVNIKOFF

The significance of this paper will be more fully understood and appreciated after a reading of the paper, begun in the December, 1940, and ended in the January, 1941, issue of this publication, under the title "The Revelation in Thunder and Storm." In that paper certain inferences were made and conclusions reached which the present paper considers unwarranted. We are pleased to give our readers the opportunity of viewing the question in the new light furnished by the scholarly paper which follows. EDITOR.

Of all the books of the Bible none is more mysterious than the Revelation of St. John. On the Isle of Patmos John saw a vision of the ultimate destiny of the Church of God and of the worldly empire. This vision with the encouragement of the victory of Christ in the very near future he addressed to the seven churches in seven cities of the Roman province Asia.

There is nothing more certain than that the visions of the apocalypse cannot be taken literally. Babylon in the vision is surely not the historic city of Babylon which by that time had ceased to exist; nor is the new Jerusalem coming down from heaven with the walls of jasper of 12,000 stades or 1,500 miles long and high and with the twelve gates of pearl to be thought of as an ordinary city. Even in small details the book cannot

be interpreted literally. Thus (Rev. 1:16), the first figure had seven stars in his right hand, which fact does not prevent him (Rev. 1:17) from placing the same right hand on John. As if warning us against literal interpretations, John explains (1:20) that in this vision seven stars represent the angels of the seven churches.

It is obvious that a cosmic philosophy underlies these visions. Eclipses of the sun and moon, falling stars, and earthquakes follow each other, and most visions are seen in the heavens. This much is admitted by all modern interpreters of the apocalypse, although the most thorough of them, R. H. Charles[1], seems to think that the author of the apocalypse did not understand the astrological significance of the images used by him. We might say the situation is analogous to a modern English speaking person's using the word "Monday" without any association with the moon, or the word "panic" without any reference to the pagan god Pan.

Charles has emphasized the importance of Hebraistic elements in the apocalypse. On the other hand, researches of Cumont[2] and Boll[3] reveal such saturation of the Hellenistic world with astrological ideas that astronomical references of the apocalypse acquire a new significance. The history of the astronomical interpretation of the apocalypse is given by Charles[4]. Of the new attempts of this kind, that of F. Boll[5], one of the best authorities on Hellenistic culture, deserves attention.

The purpose of this note is the criticism of a book published by N. Morozov in Russian in 1907 and translated into German in 1912 under the title, *Die Offenbarung Johannis, eine astronomisch-historische Untersuchung*. It has been recently brought to the attention of the readers of this magazine by M. S. Kissel[6] who obviously shares Morozov's view. Morozov finds it possible to establish the exact date of the vision which turns out to be September 30, A.D. 395, in defiance of history, and to name John Chrysostom as the author of the apocalypse. In what follows I hope to show that neither the astronomical interpretation nor the chronological results obtained by Morozov deserve the slightest confidence.

I must admit that in the original Russian the book is fascinating. To certain types of minds, Morozov's method appears to be convincing. One does not notice that his method is simply picking up what fits into his theory, leaving the rest unmentioned. This is the old method ridiculed by Schopenhauer. Throw a handful of rice on the floor. Remove all the grains that do not make significant figures, such as letters of the alphabet. Attach significance to the remaining grains.

Morozov's theory was accepted by me wholeheartedly when I read this book some thirty years ago, and I was influenced by it for some time. In my excuse, I can plead that at that time I was fifteen years old. A later book by Morozov is even more fantastic. It concerns the prophets, and he tries to show, by the astronomical method, that they lived after the time of John Chrysostom!

Since the crux of the problem is in the chronological investigation made possible by the position of the planets and the eclipse of the sun, I shall restrict my remarks only to this aspect of the book.

Morozov's reasoning is briefly the following: The procession of the four horsemen of the apocalyptic vision (Rev. 6:2) is taken to mean four planets which are identified mainly by the color of the horses; namely, the white horse with Jupiter, the red one with Mars, the black one with Mercury, and the pale one with Saturn. The constellations in which the planets were supposed to have been at the time of the vision were identified from the description of the riders. Thus Mercury was in Libra because the rider of the black horse had scales in his hand. Finally, the vision of "a woman clothed with the sun and the moon under her feet" (Rev. 12:1) is taken to mean an eclipse of the sun occurring when the sun was at the feet of the constellation Virgo. Approximate calculations showed that an eclipse of the sun on September 30, A.D. 395, would satisfy the assigned positions of the planets. Morozov's assignment of the planets to the corresponding constellations for that date was later confirmed by rigorous calculations carried out by two Poulkovo astronomers, Liapin and Kamensky. At first glance this application of the astronomical method to historical problems seems to be very convincing until one begins to analyze its logical and historical basis. Of course, the woman of the vision may very well mean the constellation Virgo, or the dragon (Rev. 12:3), the constellation Hydra. This does not mean, however, that the vision contains the chronological elements which make it possible to determine the date and hour of the vision.

Any exact assignment of the planets to the constellations (such as the moon at Virgo's feet) is hopeless. Modern constellations are not always the same as the ancient ones, and too little is known about their evolution to be sure of anything. Neither the position of the figures nor their extent has been invariable. Taking Virgo again as an example, we find it pictured with the head toward Leo on the early Roman planisphere of Geruvigus,[7] with the head toward Scorpio in the Babylonian zodiac,[8] with the head toward the celestial pole in the Egyptian zodiac of Dendera,[9] and with the head away from the pole in another Egyptian zodiac described by Daressy.[10] Therefore, the expression, "the moon at Virgo's feet," is rather meaningless unless we establish the system of the zodiac used. Nor is there much certainty about the attributes of the figures representing the constellations. Virgo, again, although always preserving the semblance of a woman (a mermaid in the Babylonian zodiac!), was pictured with wings or without wings, as Astraea, Irene, Isis, etc. Although she has always had an ear of corn in her left hand, in her right hand she has had an olive branch, a palm branch, scales, a child, or even a sword. Remembering that Orion also has a sword and that Hercules[11] was sometimes represented with a sword instead of the familiar club, the assertion of Morozov that Perseus is the only constella-

tion with a sword seems a slight overstatement. That was his justification for putting Mars in Aries, "under Perseus." No matter where you put Mars, it is always possible to find a nearby constellation with a sword.

According to Morozov, the author of the apocalypse recorded what he saw, as indeed, is explicitly stated by the seer himself (Rev. 1:2), yet Morozov comes to the conclusion that the eclipse was not visible in Patmos, that Mars was under the horizon at the moment of the vision, and that anyway the eclipse occurred at 5:00 P.M. and no planets or stars could be seen at that time. Thus, a *reductio ad absurdum* is complete.

Coming now to the identification of the planets, one is struck with the arbitrariness of assignment. Why are there only four planets participating in the procession? To be sure, the sun and the moon are assigned places elsewhere, but the omission of the planet Venus seems strange. At the supposed time of the vision Venus was in Ophiuchus just a few degrees southeast of Saturn. If the reference to the "bright and morning star" (Rev. 22:16) has any astronomical significance, it must mean the planet Venus, but this planet was near its eastern elongation and was, therefore, an evening star. This fact is conveniently overlooked by Morozov.

The identification of the planets as horses of different colors cannot be said to be based on anything but imagination. The question of the color of the planets in ancient literature was discussed in great detail by Boll and Bezold in their exhaustive investigation, *Antike Beobachtungen farbiger Sterne*.[12] Although actual words describing the color differ from author to author, the general ideas expressed by them were fairly consistent. We have the following scheme:

		Apocalyptic Horses	
Mercury:	yellowish or bluish	μέλας	black
Venus:	white	—	—
Mars:	red	πυρρός	red
Jupiter:	white and gray	λευκός	white
Saturn:	black[13]	χλωρός	pale

We see that with the exception of Mars the apocalyptic colors have little in common with the colors of the planets. Morozov tries to make μέλας mean inconspicuous, but by no stretch of imagination is this possible. The meaning of the word is plain black, as black as ink, τὸ μέλαν being the Greek word for ink. Referring to the eclipse of the sun just a few lines down, the seer says, "ὁ ἥλιος ἐγένετο μέλας" (Rev. 6:12), and no one will maintain that the sun in eclipse is inconspicuous. This same word μέλας was used by the ancients in connection with Saturn and never with Mercury. The situation is no better with Jupiter. The horse is λευκός or pure white, used to describe Venus and not Jupiter. Now, if the apocalyptic horses really were planets, we should identify them as follows: the black horse with Saturn, the red one with Mars,

the white one with Venus, and the pale one with Mercury. Morozov's scheme, therefore, falls to pieces.

But why should the horses be indentified with the planets? I do not believe there is a single instance in ancient literature to allow this interpretation. The planets were *πρόσωπα*, that is, faces or persons,[14] which might ride horses, but not *vice versa*. Indeed, in the phantasmagorical but beautiful imagery of the apocalypse, a centaur Sagittarius riding a horse Jupiter is grotesque.

There are other horses in the vision which were overlooked by Morozov. There were 200,000,000 horsemen (Rev. 9:16) ; there were countless locusts that looked like horses (Rev. 9:7) ; there were the armies of the heaven on white horses (Rev. 19:14), and, above all, the Faithful and True sitting upon a white horse (Rev. 19:11) described very much in the same fashion as the horseman identified with the planet Jupited. Are these also planets?[15]

The eclipse of the sun, which supplies the most exact date of the event, is not very convincing. "The sun became black as sackcloth of hair, and the moon became as blood," (Rev. 6:12). If the first part of this quotation is an adequate description of the solar eclipse, the second part describes just as well the eclipse of the moon. Do we have, then, a simultaneous eclipse of the sun and the moon with an earthquake and a meteoric shower to boot ("and the stars of heaven fell unto the earth") ? A little later when the fourth angel sounded, the third part of the sun and of the moon was darkened, and a third part of the stars (Rev. 8:12). Again, then, a partial eclipse of the sun and of the moon with something unheard of happening to the stars? Such passages should deter anybody from the attempt to take the apocalypse literally.[16]

The interpretation of the "woman clothed with the sun, and the moon under her feet" (Rev. 12:1) as the conjunction of the sun and the moon resulting in an eclipse is altogether not tenable. The garments of the woman are here described, the expression, "*γυνὴ περιβεβλημένη τὸν ἥλιον*," referring without question to the sun in the upper part of the figure worn as a cloak. Also the crown of twelve stars not mentioned by Morozov belongs to this vision as part of the attire of a queen. Obviously we have to deal here with a complex cycle of Regina Coeli, discussed in detail by Boll.[17]

But the reader may say, "Morozov's hypothesis has worked so well. Did not the Poulkovo astronomers confirm by exact computations the positions of the planets as assigned by him on the basis of the apocalypse text? Does not that prove the essential correctness of his hypothesis?" Not in the least. The exact computations did nothing but to check Morozov's rough results. Morozov started with the assumption of Jupiter in Sagittarius, Saturn in Scorpio, and the eclipse of the sun occurring at the end of September or at the beginning of October. The only two unassigned planets were Mercury and Mars. Mercury, being close to the sun, must have been not far from the feet of Virgo, that is, either

in Virgo or in Libra. It happened to be in Libra. So far as Mars is concerned the designation "under Perseus" or under any constellation with a sword is too indefinite.

The procedure, therefore, boils down to this: Jupiter, Saturn, the sun, and the moon are assigned their places within the wide limits of the constellations. Select, then, the years satisfying these conditions, and select from these years those which satisfy also the conditions for Mercury and Mars. There is no proof here of anything but the obvious truth that given a sufficiently long time a stated configuration of the planets is bound to occur.

What is the result? The date fixed by Morozov for the vision is September 30, A.D. 395, and the author of the apocalypse is none other than John Chrysostom. This is nothing but sheer nonsense. When I mentioned Morozov's theory to a classic scholar, his reply was that it sounded like saying that the Canterbury Tales were written not by Chaucer but by Lord Byron. The style of the apocalypse is absolutely unique. There are so many Hebraisms in it that it is generally accepted that the author was a Jew thinking in Hebrew and writing in Greek.

In so far as the date of the apocalypse is concerned, the date of few books of the New Testament has been better established. The apocalypse is mentioned by many authors before A.D. 395, often with long quotations from it verbatim.[18] There is abundant evidence that the apocalypse was in circulation both in the West and in Asia during the second half of the second century. Historical research has established beyond much doubt that the apocalypse was addressed by a person of influence and authority to seven of the leading churches of Asia between the years A.D. 90 and 96. It was written during the persecution of the Christians by the Emperor Domitian. A few historians differing from this interpretation assign it to the persecution by the Emperor Nero, that is, still earlier. Its author is unknown, and there is no conclusive proof either for or against the authorship of the Apostle John, as has been generally maintained from the second century onward.

References

[1] See his *Studies in the Apocalypse*, 1913, and especially his *Commentaries*, 1920, two volumes of the most minute analysis of the apocalypse.

[2] *Les Religions orientals dans le Paganisme Romain*, sec. ed., 1929, Ch. 7.

[3] *Sphaera*, 1903.

[4] *Studies*, p. 50 ff.

[5] *Aus der Offenbarung Johannis*, 1914.

[6] *Popular Astronomy* **48**, 537, 1940, and **49**, 13, 1941.

[7] B. Brown, *Astronomical Atlases, Maps, and Charts*, 1932, frontispiece.

[8] E. Zinner, *Geschichte der Sternkunde*, 1931, p. 57.

[9] F. Boll, *Sphaera*, plate 3.

[10] *Ibid.*, plate 6.

[11] *Ibid.*, p. 102.

[12] *Abhandlungen der K. Bayerischen Ak. der Wiss., Phil.-philol. und. hist. Klasse*, **30**, 1 Abh., 1916.

[13] Designation "black" seems strange in connection with any planet. Boll thinks that Saturn being the farthest planet was assigned the last color on the ancient color scale from white to black.

[14] W. Gundel, *Dekane und Dekansternbilder*, 1936, p .248 ff.

[15] Needless to stay, the apocalypse cannot be understood without a comparative study of other canonical and non-canonical books of the Bible. The horsemen of the apocalypse are obviously analogous to the groups of horses of similar colors in the vision of Zechariah (6:2), in which they are explained to represent the winds of the four corners of the earth. The problem of the horses and riders is fully treated by Boll, *Aus der Offenbarung*, Ch. 6.

[16] There are many references in the Bible to the eclipse of the sun and moon. (See, for instance, Mark 13:24.) An astronomical interpretation of such references would be ridiculous. They are simply an allegorical prophecy of great events.

[17] *Aus der Offenbarung*, Ch. 7.

[18] See, for instance, Irenaeus, "Against Heresies," Book 5, ch. 26 ff. Irenaeus was Bishop of Lyons. He died about A.D. 220. In A.D. 180 Irenaeus knew of certain copies of the apocalypse already "ancient." Justin in A.D. 135 speaks of the apocalpse as a recognized Christian book and identifies its author with the Apostle John (H. B. Swete, *The Apocalypse of St. John*, second ed. p. cvii).

MARCH 4, 1941,

The Addition to the Warner and Swasey Observatory

By J. J. NASSAU

The significant addition to the Warner and Swasey Observatory of the Case School of Applied Science was made possible through the gensersosity of relatives and associates of the original founders, Mr. Worcester R. Warner and Mr. Ambrose Swasey, as well as other friends of the institution. A sum of more than $213,000.00 was raised which will provide for the following:

THE TELESCOPE. A Schmidt-type telescope of 37-inch mirror and 24-inch lens is the gift of Mrs. Katherine Burrell in memory of her husband, Dr. E. P. Burrell, the late director of engineering at the Warner and Swasey Company. The mirror is of pryrex glass and the lens is of Vita-glass. The focal length of the instrument is 84 inches. It will be provided with a circular plate-holder of 8 inches diameter and will have a field of 5°.4. The mounting will be of the cross-axis type and will be driven by a synchronous motor. The optics and mounting are now under construction at the Warner and Swasey Company's shop. Provisions are made for an objective prism of 24-inch diameter having an angle of 4°.

An auxiliary refracting telescope of 9.5-inch lens will be attached to the tube of the Burrell telescope and will be used primarily for guiding. This refractor is the gift of Mr. Frederick Dorn and his mother.

THE DOME. The internal diameter of the dome is 28 feet, the covering is sheet copper heavily insulated. A double shutter provides an opening of 6.5 feet and will permit continuous exposure for half an hour at the equator without moving the dome. Two wind curtains complete the dome equipment, all moving parts of which are motor driven.

THE AUDITORIUM. Mrs. Worcester R. Warner and her daughter, Miss Helen Warner, contributed the sum of $95,000.00 for the building of the Warner Memorial Auditorium. This provides for its complete equipment and maintenance as well. The seating capacity is for 128 persons. The foyer and exhibit hall entrance provide ample space for educational exhibits. The public activities of the observatory are centered around the auditorium, that is, visitors' nights and lectures in connection with the Cleveland Astronomical Society.

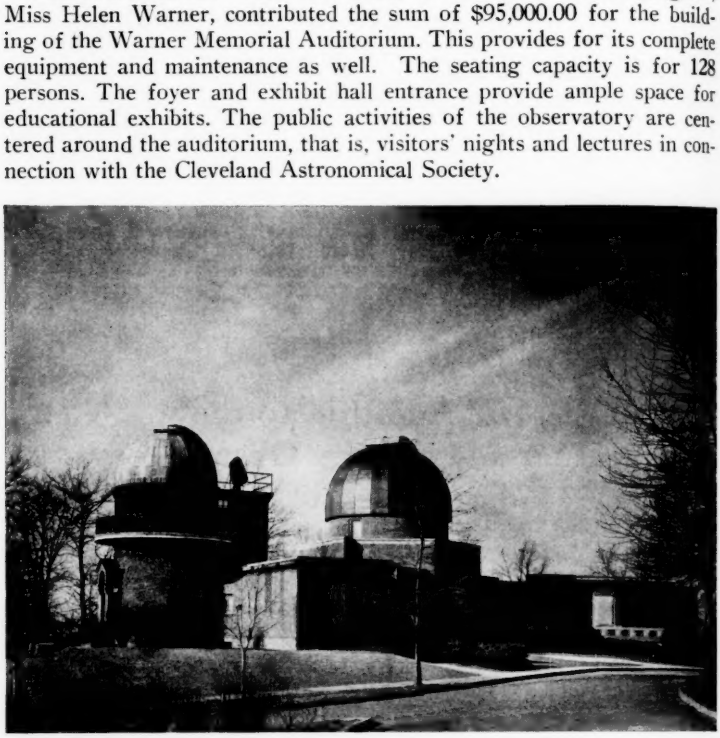

Photo by C. W. Ackerman

THE WARNER AND SWASEY OBSERVATORY

On October 25, 1940, Dr. Otto Struve gave the initial address in the auditorium, speaking to the members and friends of the Cleveland Astronomical Society. His subject was, "The Mystery of Beta Lyrae." Upon this occasion Miss Helen Warner unveiled a portrait of her father, which has been placed in the foyer.

LABORATORY ROOMS. Two laboratory rooms, one of which is designed primarily for photometric work, are located on the first floor. A new Schilt-type photometer has been built under the direction of Dr. A. L. Bennet at the Yale Observatory shop.

The sum of $12,900 has been provided by Mr. and Mrs. W. J. Henderson for scientific equipment for the Observatory.

LIBRARY. It is now possible to house the complete library of the department at the Observatory, a large room for this purpose has been built on the first floor.

SHOP. The shop also is located on the first floor. Its equipment was donated by the Dorn family in memory of Mr. Harry Dorn, a former Case student.

OFFICES. Two offices are located on the second floor and command an excellent view of Lake Erie.

The building is of brick and steel construction and it is in harmony with the old building. Beautiful landscaping surrounds the entire building. The dedication of the Observatory will take place upon the completion of the telescope.

MARCH 21, 1941.

Planet Notes for June, 1941

By R. S. ZUG

NOTE: Greenwich Civil Time is employed unless otherwise stated. To obtain Eastern Standard Time subtract 5 hours, Central Standard Time, 6 hours, etc. The planetary phenomena are described as they are to be seen from latitude 45° N. The data are taken chiefly from the *American Ephemeris and Nautical Almanac.*

Sun. During June the sun will be moving eastward through the constellations Taurus and Gemini. The season of summer begins June 21, $19^h\ 34^m$, when the sun reaches the summer solstice.

Moon. Phenomena of the moon will occur as follow:

		h	m
First Quarter	June 2	21	56
Full Moon	9	12	34
Last Quarter	16	15	45
New Moon	24	19	22
Perigee	June 8	2	
Apogee	20	7	

Mercury. Mercury will be a conspicuous evening star for a few days preceding and following June 6, the date of greatest eastern elongation. The greatest elongation will be 23° 47′ which will be attained June 6, 4^h (10:00 P.M., June 5, Central Standard Time). The stellar magnitude of the planet will be +0.7 at the time of greatest eastern elongation. It will be found in the constellation Gemini.

Venus. Venus is now visible in the evening sky. For distance, angular diameter, etc., reference may be made to p. 30 of POPULAR ASTRONOMY, January, 1941.

Mars. Mars will reach western quadrature June 2, and, during June, will rise a little before midnight. The planet will be moving through the constellation Aquarius until the last few days of June when it enters Pisces. On June 30 the planet will be located on the equinotical colure, 3°.5 south of the vernal equinox. Numerical data follow:

Date 1941	Distance from Earth (miles)	Angular Diameter	Stellar Magnitude
June 1	91,722,000	9".5	+0.1
15	83,163,000	10.5	−0.1
30	74,462,000	11.7	−0.4

Information enabling observers to identify the Martian longitude of the center of the planetary disk and the surface markings visible at any time may be found on pages 30-32 of POPULAR ASTRONOMY for January, 1941.

Jupiter. Jupiter is a morning star.

Saturn. Saturn is also to be found in the morning sky.

Uranus. Uranus is a morning object but too close to the sun for observation.

Neptune. Neptune will be in eastern quadrature on June 16, and will be nicely observable in the evening sky during June. The apparent motion of the planet becomes direct on June 6. The planet may be located telescopically with the aid of the chart which appears on p. 35 of the January, 1941, issue of POPULAR ASTRONOMY.

Asteroid Notes

By HUGH S. RICE

During May we still have the situation of all 4 of the largest asteroids being visible in the night sky. We summarize below the approximate positions well enough that they may be plotted onto star charts and observed with small telescopes. The positions are for 0^h universal time, except in the last column.

Asteroid	Mag.	May 2	May 18	June 3	Remarks
Ceres	7.8	5° n.w. σ Sgr	$4\frac{1}{2}$° from σ Sgr	1° n.e. λ Sgr	Close to Messier objects.
Pallas	8.6	$4\frac{1}{2}$° s.w. by w. δ Her.	7° w. σ Her	$4\frac{1}{2}$° n. β Her	Retrograde.
Juno	9.8	5° w. α Leo	2° w. α Leo	2° s.e. α Leo	Conjunction with Regulus, $26^d.5$ E. S. T., Juno $\frac{1}{2}$° south.
Vesta	7.4	3° s.w. ϵ Leo	7° w. γ Leo	3° s.w. γ Leo	Conjunction with moon, May 5, 0^h E. S.T., Vesta 11° north.

HAYDEN PLANETARIUM, AMERICAN MUSEUM OF NATURAL HISTORY,
NEW YORK CITY, APRIL 16, 1941.

Occultation Predictions

(Taken from the *American Ephemeris*)

OCCULTATIONS VISIBLE IN LONGITUDE +72° 30′, LATITUDE +42° 30′

Date 1941	Star	Mag.	IMMERSION Greenwich C.T.	IMMERSION a	IMMERSION b	IMMERSION Angle E from N	EMERSION Greenwich C.T.	EMERSION a	EMERSION b	EMERSION Angle E from N
			h m	m	m	°	h m	m	m	°
June 1	222 B. Cnc	6.3	2 11.8	—0.4	—1.4	99	3 10.8	0.0	—1.8	298
5	*m* Vir	5.2	22 54.5	—1.2	+0.4	109	0 5.5	—1.3	—0.2	300
8	θ Lib	4.3	5 48.2	—1.4	—1.1	102	6 57.8	—1.1	—1.3	275
11	B.D.—18°5155	6.3	4 35.2	—1.8	+2.0	45	5 33.1	—1.7	—0.6	309
11	187 B. Sgr	6.4	9 1.5	..	..	143	9 31.8	..	..	194
13	95 B. Cap	6.0	6 32.4	—2.1	—0.5	129	7 19.0	—1.3	+2.6	200
15	67 Aqr	6.3	7 47.7	—0.9	+3.2	14	8 37.5	—2.5	—0.6	301
29	83 B. Leo	5.9	1 39.5	+0.2	—2.6	156	2 18.1	—0.1	—0.7	242

OCCULTATIONS VISIBLE IN LONGITUDE +91° 0′, LATITUDE +40° 0′												
June 1	222 B. Cnc	6.3	2	4.7	−0.8	−1.9	121	3	10.8	−0.6	−1.6	280
8	θ Lib	4.3	5	19.3	−1.8	−0.7	111	6	35.3	−1.7	−0.8	273
11	B.D.−18°5155	6.3	4	2.3	−1.2	+1.8	64	5	5.7	−1.2	+0.3	296
11	187 B. Sgr	6.4	8	23.0	−2.3	−1.4	126	9	17.8	−1.2	+1.1	214
13	95 B. Cap	6.0	6	6.3	−1.0	−0.5	136	6	45.7	−1.4	+3.2	201
15	67 Aqr	6.3	7	24.3	..	..	6	7	56.1	..	..	316
OCCULTATIONS VISIBLE IN LONGITUDE +120° 0′, LATITUDE +36° 0′												
June 7	22 B. Lib	6.4	1	56.5	−1.4	+2.4	64	2	40.7	−0.3	−1.6	339
8	θ Lib	4.3	4	40.5	−0.8	−1.4	152	5	34.0	−2.4	+1.5	243
11	187 B. Sgr	6.4	7	30.1	−1.4	−0.8	137	8	21.1	−2.1	+2.3	218

The quantities in the columns *a* and *b* are given for the purpose of making these predictions useful for any place within 200 miles of the point indicated. The procedure is as follows: Subtract the longitude of the point given from the longitude of the place in question; multiply the result in degrees, taking the signs into account, by the quantity under *a* for the star to be observed; similarly, with the latitude, using *b*; apply the sum of the products, with its proper sign, to the Greenwich C.T., and obtain the predicted Greenwich Civil Time for the phenomenon at the place of observation. To obtain Eastern Standard Time it is necessary to subtract five hours; Central Standard Time, six hours, etc.

METEORS AND METEORITES

Contributions of the Society for Research on Meteorites

Edited by **FREDERICK C. LEONARD,**
Department of Astronomy, University of California, Los Angeles

President of the Society: H. H. NININGER, Colorado Museum of Natural History and American Meteorite Laboratory, Denver

Secretary of the Society: ROBERT W. WEBB, Department of Geology, University of California, Los Angeles

A Mathematical Formula for Meteoritic Age-Determination and its Application to the Pultusk, Poland, Meteorites*

By LINCOLN LA PAZ,
Department of Mathematics, Ohio State University, Columbus

Until very recently, meteorites have been regarded as disintegration products. It has been believed that under the disruptive effects of planetary and solar perturbations an original parent mass of cometary or larger dimensions has been broken up into fragments which continued the comminutive process by collisions among themselves. In 1938, A. Corlin[1] suggested that the actual course of events might be the reverse of the one just outlined. He described a process by which, under electrostatic attraction, coalescence of the infinitesimal particles which pervade interstellar space might take place, producing initially tiny meteoritic

*Read at the Sixth Annual Meeting, Richmond, Virginia, December, 1938. For an *abstract*, see *C.S.R.M.*, **2**, No. 2, 111-12; *P. A.*, **47**, 276-7, 1939.

cores and then, in the course of ages, larger and larger meteorites and eventually comets. This theory, although bitterly attacked by several critics,[2] has been ably and apparently successfully defended by its author, at least in so far as aërolites are concerned.[3] It is the purpose of the present paper to call attention to an additional item of evidence supporting Corlin's theory of the origin of this class of meteorites.

In 1932, F. A. Paneth, at the suggestion of H. Shapley, made a determination of the age of the Pultusk, Poland, meteorites by the so-called helium method which Paneth had earlier employed with much success on iron meteorites. At first sight the application of the helium method to a stony meteorite might seem illegitimate because the "helium-tightness" of a stone is considerably less than that of a dense iron. However, escape of helium from an aërolite like a Pultusk stone, which we have excellent reasons for believing has been for most of its life at the low temperatures of interstellar space,[4] would not be expected to exceed helium loss from similar terrestrial rocks which in the course of Earth history have not been exposed to elevated temperatures and hydrothermal alteration. For such rocks, as is amply confirmed by the work of Urry,[5] the helium method of age-determination appears to be reliable. In fact, a detailed study of inclusions of Pre-Cambrian rocks in the kimberlite of the famous South African diamond pipes recently made by Holmes and Paneth[6] indicates that at least the *order* of the ages of such inclusions can be inferred from their helium content unless the included material is coarse-grained and has been subjected to such high temperatures and such intense alteration by hydrous emanations from the kimberlite magma responsible for the formation of the pipes that the contained helium has been lost. In spite of the fact that we have no reason to believe that the Pultusk material has been subjected to such extremes of temperature and alteration, the age, 5×10^8 years, deduced for it from Paneth's study of specimens of these aërolites, has been very generally regarded as much too low[7] and the suggestion has actually been made that in the process of Paneth's experimentation helium gas originally present in the meteoritic material was allowed to escape. To one familiar with the excessive precautions taken in Paneth's experimental work, this explanation does not seem probable. Furthermore, no one seems to have published a redetermination of the age of the Pultusk aërolites conflicting with Paneth's result, although there is great activity in the field of meteoritic age-determinations at the present time.* It seems to be worth while, therefore, to assume provisionally that Paneth's age-determination for the Pultusk stones is correct and to seek to explain the low value obtained by him. It appears that a possible explanation is afforded by the hypothesis that the Pultusk

* Since these words were written, the following important evidence confirming Paneth's result has come to light: In 1939, Schumb, Evans, and Hastings (*Jour. Am. Chem. Soc.*, **61**, 3451-5, 1939) showed by a method quite distinct from that of Paneth that the Pultusk meteorites and a certain specimen of Ontario granite (KDFine) were of nearly the same age. The specimen of granite in question was collected personally by Dr. N. B. Keevil of the Department of Physics of the University of Toronto. In a personal communication to the writer under date of January 20, 1941, Dr. Keevil states that his investigations of this specimen of granite by the helium-radioactivity method "would indicate the true age as about 550 million years." After reading the manuscript of the writer's paper concerning the age of the Pultusk meteorites deduced by means of Corlin's theory, Dr. Keevil decided to determine the age of the KDFine granite more accurately, "if a sufficient sample of a suitable mineral can be separated." The results of this redetermination will be awaited with much interest.

meteorites had their origin in the electrostatic accumulation of particles in interstellar space.

According to Corlin's theory, if m_1 denotes the meteoritic core mass (in g.) and T the time (in years) required for m_1 to build up into a meteorite of mass m_2 (in g.), then m_1, m_2, and T are related by the equation

$$(1) \qquad \sqrt[3]{m_2} - \sqrt[3]{m_1} = (k_e/3) \times T,$$

where k_e is a constant which Corlin evaluated by taking as m_1 the mass, 10 g., of the sideritic specimens employed in Paneth's famous series of age-determinations for iron meteorites and by assigning to m_2 the value 10^6 g. (adopted as the average mass of *recovered* meteorites) and T the value 10^9 years (adopted as the average age resulting from Paneth's work on iron meteorites). This method of evaluating k_e is open to several obvious objections, the chief of which relates to the identification of m_2 with *recovered* mass rather than *extra-atmospheric* mass.[8]

An alternative method for appraising k_e, not open to these objections, is to assume that the *hyperbolic* comets represent the end products of the process of electrostatic accumulation and hence that the average mass of such comets represents the average mass m_2 built up by this process out of a negligible core-mass m_1 during the lifetime, T, of the Galaxy. If we assign to T the value 5.5×10^{19} years and to m_2 the value 6×10^{18} g. (the average of recent cometary mass-determinations), we find that $k_e = 9.9 \times 10^{-8}$ g. per year. On the basis of this result and (1), the age, t, of a meteorite of *extra-atmospheric* mass m_2 g., which has been produced solely by electrostatic accumulation, is given by the simple formula

$$(2) \qquad t = (\sqrt[3]{m_2} \times 10^8)/3.3 \text{ years.}$$

Unfortunately, since we have, at present, no means of measuring the extra-atmospheric masses of meteorites, t cannot be computed from (2) unless it is possible to calculate m_2 from the mass m_2' of that portion of m_2 which survives transit through the atmosphere. In general, it will be impossible to follow this procedure, for the identity of those masses m_2 produced solely by electrostatic accumulation will usually be lost because of fragmentation incident to their passage through the atmosphere. However, in the case of a shower (like that of Pultusk, as described by Galle) for which no explosion occurs, the extra-atmospheric bodies may preserve their identity, even if they lose most of their mass as a result of ablation during flight. Our problem in any particular case reduces, then, to the determination of the relation between m_2 and m_2', under the usual simplifying assumptions that the meteorite is a sphere and that, in the process of ablation, successive spherical shells concentric with the original surface of the meteorite are removed.

This problem can be simplified further by the observation that a shower like Pultusk, which before transit through the atmosphere consisted of a number of distinct meteorites endowed with a common motion, must, under the Corlin hypothesis, have arisen from the simultaneous development of electrostatic accumulation of a number of meteoritic granules, initially of equally negligible mass, which from the beginning pursued parallel, neighboring paths through space and which were, therefore, subject to essentially the same vicissitudes of growth. At any stage in the life history of such a developing meteoritic swarm and hence, in particular, at the moment of impact with the atmosphere, the majority of these bodies must have had nearly the same mass, m_2. Departures from such regularity of mass would result chiefly from gravitational attraction between members of the

swarm. Under suitable conditions such attraction might result in the gradual junction of 2 or more partially-grown meteorites and the subsequent development of a single meteorite with a mass approximately equal to some integral multiple of m_2. The opposite and probably more frequent effect would be collision at such velocities as to produce fragmentation and recoil.

Of course such regularity of size is not to be expected among the meteorites actually recovered from the shower, for the ranks of the tinier fragments will be augmented not only by débris from the less substantial and less symmetrically shaped complete individuals, which will tend to break up before or at impact with the Earth's surface, but also by fragments of the smaller meteorites, stalled by air resistance and then struck from behind by larger meteorites upon which the atmosphere exerts a relatively feebler braking action.

The remarks just made suggest that, in our effort to identify those masses m_2' which arise from the ablation of the masses m_2, we should exclude from consideration not only the few recovered meteorites of exceptionally high mass but also the vast number of tiny particles ranging downward to mere dust which have resulted from the ablation of fragmentary meteoritic material rather than complete meteorites. After such exclusion, those of the remaining meteorites which exhibit neither secondary crusts nor other evidence of an origin from fragmental material are most likely to be the surviving portions of the extra-atmospheric masses m_2. In practice, identification of such survivors by the method just outlined is rendered very difficult, not only because certain selection factors influence the mass of the meteorites recovered and preserved, but also because identification of members of the fragmental subgroup may be made difficult or impossible by ablation, subsequent to disruption, which may conceal all evidence (such as rough fracture surfaces) of fragmentation. In view of these difficulties and the fact that in the typical collection of *complete individuals* of the intermediate group the inclusion of a few masses of somewhat too high mass will be nullified by the inclusion of a great many specimens of very small mass, it has seemed best to employ as m_2' the *average mass* of the individuals in such collections. From 845 Pultusk specimens, Daubrée,[9] who seems to have taken pains to exclude the smaller masses arising from fragmentation, obtained an average mass of 73.9 g., in fair agreement with the average value of 61.2 g., found for the Kranz[10] collection of 2,012 Pultusk meteorites. The mean of these 2 determinations, *viz.*, 67.5 g., will be adopted as the mass m_2' of that (central) portion of an extra-atmospheric mass of m_2 g. which, in the case of the Pultusk fall, survived transit through the atmosphere. If this evaluation is correct, then one would expect the masses of complete Pultusk meteorites of the *intermediate* size group to cluster around the value 67.5 g. It would be interesting to determine whether or not they do so.

We are now in position to ascertain the relationship between m_2 and m_2'. In the case of recovered complete individuals of the size of the Pultusk specimens of the intermediate group (67.5 g.), there is a considerable amount of evidence indicating that approximately 99% of the original extra-atmospheric mass m_2 has evaporated during flight through the atmosphere;[11] or, in other words, that

$$m_2' = 0.01\ m_2. \tag{3}$$

But from the relation (3), we have at once

$$t = \sqrt[3]{[100\ m_2']} \times 10^6/3.3. \tag{4}$$

On substituting $m_2' = 67.5$ g. in (4), we find that the age of the central part

of the Pultusk stones of the intermediate group is $t = 5.7 \times 10^8$ years—in good agreement with Paneth's result of 1932.

In view of the fact that future careful examination of individual Pultusk stones may show that the value adopted (*ante*) for m_2' is too small, it is worth while to recompute t by using the *largest admissible* value for m_2'. All available evidence indicates that m_2' cannot possibly exceed 1000 g. Starting from the relation (3), we can show by use of the writer's theory of the percentage loss caused by ablation in meteorites of different sizes,[12] that, for a recovered complete individual with mass $m_2' = 1000$ g., approximately 89% of the extra-atmospheric mass has evaporated during passage through the air. We have, therefore, in this case

$$m_2' = 0.11\ m_2, \tag{5}$$

and hence

$$t = \sqrt[3]{[9.1\ m_2']} \times 10^8/3.3. \tag{6}$$

For $m_2' = 1000$ g., (6) gives $t = 6.3 \times 10^8$ years, another result in satisfactory agreement with the age-determination of Paneth.

NOTES

[1] Corlin, A., *Zeits. f. Astrophys.*, **15**, 239-62, 1938.
[2] See, *e.g.*, Lönnquist, C., *Zeits. f. Astrophys.*, **17**, 344-54, 1939.
[3] Corlin, A., *Zeits. f. Astrophys.*, **18**, 1-24, 1939. The chief modification which Corlin has felt obliged to make in his statement of the theory of the electrostatic accumulation of meteorites relates to the source of the electrostatic charge responsible for coalescence of interstellar particles. Originally, this charge was credited to cosmic-ray bursts; but, in his last paper, Corlin accepts ionization caused by starlight as the principal source of the charge. However, he continues to regard cosmic-ray bursts as determining the limiting radius of permanently charged bodies and points out that the *rate* of mass-increase, as a function of the mass, is the same for charges caused by starlight as for those produced by bursts.
[4] *Cf.* Öpik, E., *P. A.*, **41**, 76-7, 1933.
[5] Urry, W. D., *Chem. Rev.*, **13**, 305, 1933, and *Rep. Comm. on the Measurement of Geol. Time*, National Research Council, Washington, 1935.
[6] Holmes, A., and Paneth, F. A., *Proc. Roy. Soc.* (London), *A*, **154**, 385-413, 1936.
[7] *Cf.* Evans, R. D., *C.S.R.M.*, **2**, No. 1, 16-27; *P. A.*, **46**, 159-70, 1938.
[8] La Paz, L., *Astr. Nach.*, **267**, 107-12, 1938.
[9] Daubrée, Auguste, *Comp. Rend. Acad. Sci.* (Paris), **67**, 369, 1868.
[10] Paneth, F. A., *Nature*, **140**, 809, 1937.
[11] See, *e.g.*, Wimperis, H. E., *Nature*, **71**, 82, 1904.
[12] See (8), *ante*; *loc. cit.*, p. 110.

Contraterrene Meteorites

By LINCOLN LA PAZ

ABSTRACT

This note is in reply to the unfounded objections of H. H. Nininger (*C.S.R.M., P. A.*, **49**, 215-16, April, 1941) to the writer's paper on contraterrene meteorites (*ibid.*, 99-102, February, 1941; *C.S.R.M.*, **2**, No. 4, 244-7, 1941).

Not all meteoriticists share H. H. Nininger's views that available evidence constitutes proof of the meteoritic origin of such topographical features as the Podkamennaya Tunguska, Siberia, funnels and other craters referred to in the writer's paper on contraterrene meteorites (see refs. in abs., *ante*). Many authorities take the stand that, irrespective of other evidence, neither craters nor silica-

glass deposits are to be accepted as due to meteoritic impact unless meteorites have been found in or near them. The chief purpose of the writer's earlier note was to point out that this uncompromising position is untenable in view of the possibility of the existence of contraterrene meteorites capable of producing craters and silica-glass without leaving behind a trace of the original meteoritic material. If those who have opposed the meteoritic origin of the craters and silica-glass deposits in question wish to continue to insist that meteorites *must* be discoverable wherever meteoritic impacts have occurred on the surface of the Earth, it is now incumbent on them to discredit the evidence, observational as well as theoretical, favoring the existence of contraterrene meteorites.

The writer is unable to accept Nininger's explanation of the repeated failures to discover meteoritic material at the site of the Podkamennaya Tunguska fall. It is not, as he implies, a question of unsystematic, superficial search, under unfavorable field conditions, for "the ordinary sprinkling of meteorite fragments around a crater." The Russian Academy of Sciences sent well-organized expeditions, elaborately equipped with excavating tools, drills, and modern geophysical equipment to the Podkamennaya Tunguska region in search of meteorites. Cabins for the numerous personnel of the expeditions and housings for boring machinery were erected at the permanent base in the central part of the area of fall and continuous investigations under the supervision of specialists in meteoritics, geology, and mining were prosecuted over periods up to 20 months in duration. On the Stony Tunguska River, as at Canyon Diablo, Arizona, systematic trenching, drilling, magnetometric surveys, and chemical analyses of subsurface deposits were carried out in the search for meteoritic material, in the former case without the recovery of a single specimen of indisputably meteoritic nature, in the latter with results well known to all. On the basis of discoveries actually made at the Arizona crater, there can be no reasonable doubt that the intensive searches made by Russian scientists would have resulted in the recovery of meteoritic material if, as Nininger asks us to imagine, the Canyon Diablo rather than the Podkamennaya Tunguska fall had occurred on the Stony Tunguska River in 1908. The negative results of long and intensive search for fragments of the *extremely recent* Podkamennaya Tunguska fall lead one to question whether it is necessary to invoke great age in order to explain the absence of recoverable meteorites, as Nininger does in the case of the Carolina Bays.

Nininger's remarks concerning tektites unassociated with craters are misleading. The careful reader of the writer's note on contraterrene meteorites will have observed that no discussion of the origin of tektites was attempted but that attention was devoted solely to certain *silica-glass deposits* differing notably from tektites but closely resembling glasses known to have been produced by the fusion of siliceous materials in the intense heat incident to meteoritic impact on the surface of the Earth. In the writer's opinion, no fact in observational meteoritics is more certainly established than that the silica-glass found at the Wabar, Arabia, Henbury, Australia, and Canyon Diablo, Arizona, meteorite craters originated in the manner just described. As cautious an authority as L. J. Spencer has finally gone on record in favor of a similar origin for Darwin glass, in spite of the fact that no meteorites have as yet been found associated with this material. Reluctance to include Libyan glass in the same category continues to be based on failure to discover meteorites in or near this deposit. The writer's earlier note suggests how such deposits of silica-glass as those just referred to might arise from meteoritic impact and yet no trace of the parent meteorites remain.

In regard to the origin of the tektites proper, it is interesting to note that,

although Nininger considers Spencer's impactite theory as supported by "but slender evidence," he has not hesitated to advance a modification of Spencer's hypothesis resting on far less substantial grounds. We refer to his conjecture that tektites have had their origin in connection with the meteoritic impacts which, he assumes, formed the craters on the Moon (see H. H. Nininger, *Bull. Geol. Soc. Am.*, **51**, p. 1936, 1940). *If* the lunar craters were known to be due to the impacts of meteorites and *if* such impacts on the surface of our satellite were known to produce molten masses, from which bodies with the chemical composition of the tektites could be derived, and to impart to these masses velocities sufficient to enable them to escape from the attraction of the Moon and *if* certain other essential conditions were known to be fulfilled, *then* Nininger's conjecture, in his own words, "might indeed afford a very handy solution to many baffling problems!"

Committee Appointments

The Executive Committee of the Council has appointed the following *Committee on Arrangements for the Eighth Meeting*, to be held at Flagstaff, Arizona, on June 23, 24, and 25, 1941: Major L. F. Brady, Chairman (Mesa and Flagstaff), Dr. C. H. Cleminshaw (Los Angeles, California), Dr. Carl O. Lampland (Flagstaff), Mr. P. G. McGough (Flagstaff), Mr. Clyde W. Tombaugh (Flagstaff), and the President and the Secretary of the Society, *ex officiis*.

Professor J. Hugh Pruett (Eugene, Oregon) has resigned from the chairmanship of the recently appointed *Committee on the Legal Ownership of Meteorites* (see announcement in the April issue) but will continue as a member of that Committee. Professor Earle G. Linsley (Oakland, California) has been appointed Chairman of the Committee in succession to Professor Pruett.

ROBERT W. WEBB, *Secretary*

VARIABLE STARS

Variable Star Notes from the American Association of Variable Star Observers

By LEON CAMPBELL, Recorder

Photographic Light Curves of l Carinae and β Doradus: During the years 1939 and the early part of 1940 the late E. G. Williams secured a number of photographic observations of the Cepheid variables, *l* Carinae and β Doradus with the 7-inch finder of the large reflector at the Radcliffe Observatory, Pretoria, South Africa. A method due to Fabry was used, employing suitable filters to obtain observations in red, green, and blue light, respectively.

The images of the variable and one or more comparison stars were measured with a microphotometer. The magnitude scale was fixed by comparison with the Pleiades, but the exact zero points are not known with certainty.

Figures 1 and 2 show the individual observations of the two variables in red, green, and blue light; smoothed curves are drawn through the points to indicate the general form of the light curves. The effective wave-lengths of the three colors may be taken as approximately 6250, 5250, and 4250, respectively.

Visual light curves, as observed over the same interval of time by Mr. A. W. J. Cousins of Durban, South Africa, are also indicated. The effective wavelength of the visual observations has been found to be near 5200 A.

The agreement between the visual and the green photographic light curves of β Doradus can be considered as satisfactory, but the curves for l Carinae suggest the probability of personal equation affecting the result. The visual observations appear to exaggerate the rate of the rise from minimum to maximum.

The difference in range of variation in light of different colors is clearly shown by the curves. The color index for l Carinae is consistently greater than that for β Doradus.

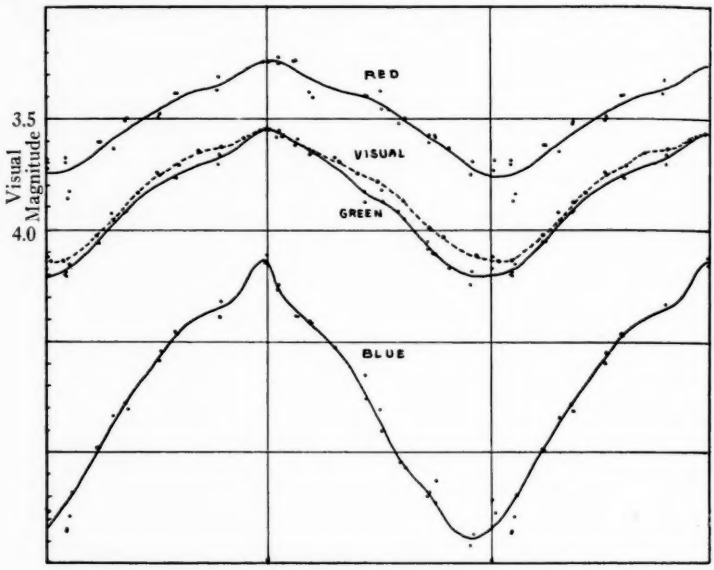

FIGURE 1

LIGHT CURVES OF β DORADUS

There is also evidence of a small difference in phase between the three photographic curves of each variable, the phases occurring earlier in blue light and later in red light than they do in green light. The differences, although small, appear to be real, and indicate that the stars are hottest just before maximum light and coolest before reaching minimum light. Similar differences have been noted for other Cepheids.

This note has been kindly supplied by Mr. Cousins with the approval of Dr. Knox-Shaw, Director of the Radcliffe Observatory.

A Third Nova in the Large Magellanic Cloud: In the systematic study at Harvard Obsrvatory of the Magellanic Clouds another nova has been found by Miss Virginia McKibben in the Large Cloud. The nova appeared sometime between November 12 and 23, 1937. On the first date it was invisible, and must have been fainter than magnitude 14.2. On November 23 it appeared for the first time at magnitude 10.7, probably then on the decrease from maximum. During the next three days it faded to the twelfth magnitude and on December 10 it had reached magnitude 13.3. At the end of January, 1938, the star had again

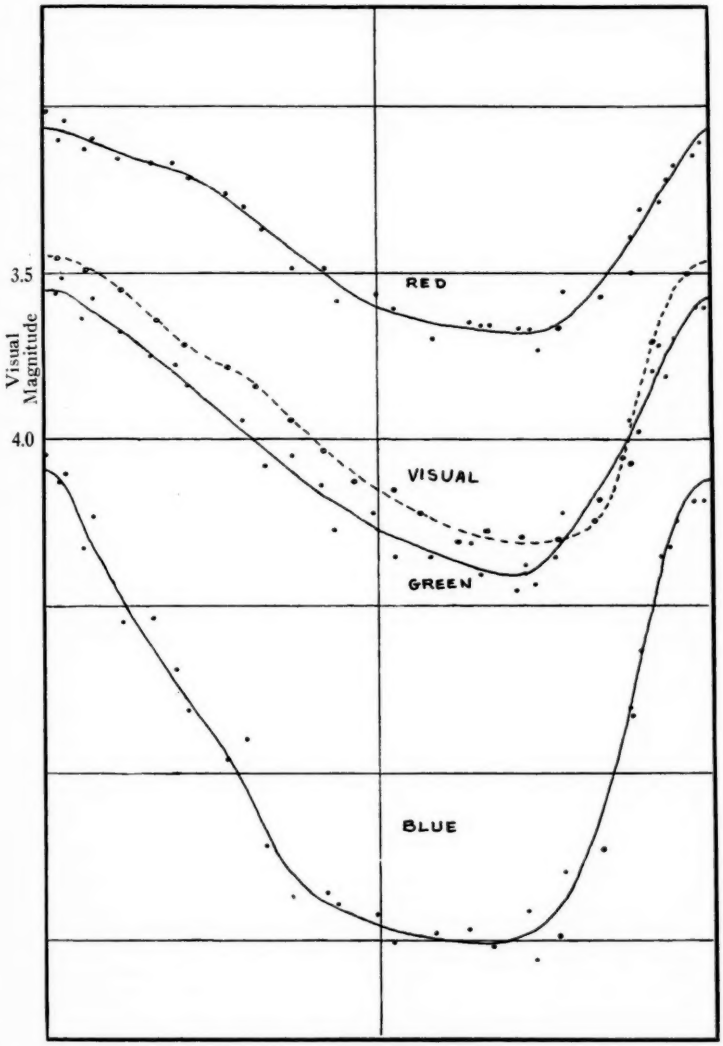

FIGURE 2
LIGHT CURVES OF *l* CARINAE

become invisible, fainter than magnitude 14.8.

With a distance modulus for the Large Cloud of 17.0, the nova appears to have attained a brilliance at least a magnitude brighter than might be expected

for novae in this system. In all probability the nova actually reached the tenth magnitude around November 20.

Only three novae have been previously detected in the Magellanic Clouds, one in the Small, and two in the Large Cloud. VZ Tucanae, discovered by Miss Hughes in the Small Cloud, appeared at maximum in December, 1927, magnitude 11.4. The nova RY Doradus in the Large Cloud, discovered by Luyten, was at maximum, magnitude 12.4, in September, 1926, and the other Large Cloud nova was found by Miss Dowse to be at maximum, magnitude 10.8, in February, 1936. To have another fairly bright nova appear in the Large Cloud less than two years later is of particular interest. The latest Large Cloud nova is located about a degree and a half distant from 30 Doradus.

U Geminorum and SS Aurigae, 1939-1940: Four maxima of U Geminorum were observed during 1939 and 1940, two very completely, and two others only fragmentarily. The two well-observed maxima occurred late in February, 1939, and February, 1940, almost exactly a year apart. Both were of the broad type, with the rise to maximum exceedingly rapid. The maximum of August, 1939, was observed on only two nights, and that of September, 1940, on only three nights. It is difficult to ascribe a classification of type to either of these. The observations, each point representing a daily mean, are shown in the upper portion of Figure 3.

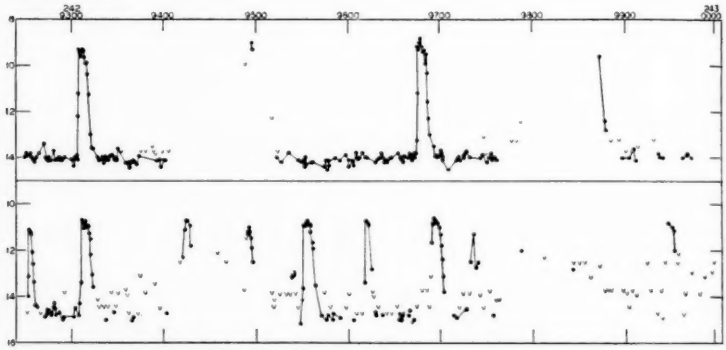

FIGURE 3

LIGHT CURVES OF U GEMINORUM AND SS AURIGAE, 1939-1940

The observed maxima of SS Aurigae were more numerous, six in 1939, and probably five in 1940, although the evidence for two of those in 1940 is very meagre, too few observations having been obtained in that year. Of the 1939 maxima, two were definitely of the broad type, and four of the narrow type. The light curve is shown in the lower portion of Figure 3.

The average length of cycle over many years for U Geminorum is 102 days, with values between 60 and 150 days. That for SS Aurigae is 54 days, ranging from 20 to 100 days.

Supernova in NGC 3254: Still another supernova has recently appeared in an external galaxy. The latest was found by J. J. Johnson of the California Institute of Technology on a plate taken on March 25, 1941, when the nova was of the fifteenth magnitude, and was confirmed on a plate taken the next night. It

appeared just south of the nucleus of the edgewise spiral nebula NGC 3254, located in Leo Minor.

The nova was also confirmed at Harvard Observatory on a plate taken on March 27, photographic magnitude 15.8. The galaxy itself has a total magnitude of 12.6.

The A.A.V.S.O. Nova Search Program: Monthly reports of the Nova Search Program, though they show only negative results to date, continue to be made by our observers. Non-members of the Association are welcomed by the Committee with the hope that the entire area of the sky may be carefully watched for the possible advent of a bright nova. A diagram showing the regions selected for particular search has been prepared and is available, at cost price, upon application to the Chart Curator of the A.A.V.S.O. With the help of this diagram and a good star atlas—the A.A.V.S.O. Atlas is especially useful for this naked eye search—one is equipped to participate in this worth-while program. Cards for reporting the observations may be had upon request to the Recorder.

Reports were received during February and March from the following observers; numerals following the names indicate the regions observed. "Dome" refers to the then visible vault of the sky on which the observer checks the presence of all known stars brighter than the second or third magnitude. In such a manner he can assure himself of the presence or non-presence of any bright nova.

Blunck	9	Maupome	101	Snyder	26, 71
Fernald	24, 34	Milnes	17, 112	Topham	Dome, 40,53
Forrester	48	Purdy	101	Yamada	19
Martin	102	Rosebrugh	Dome, 1, 34	Yamasaki	66
Mason	Dome, 111	Smith, F. W.	Dome, 3		

Spring Meeting of the A.A.V.S.O.: The thirtieth annual spring meeting of the A.A.V.S.O. is to be held at the Vassar Observatory May 30 and 31, 1941. This being the third occasion on which the Association has met at Vassar, one may hope that the meeting will be as successful as its predecessors.

The Council will meet on Friday afternoon, and the evening of that day will be devoted to a general discussion of variable star problems as they affect the observers, with an opportunity to observe variables, if weather permits.

The general meeting will be held on Saturday morning. After lunch there will be a motorcade trip to the Vanderbilt National Historic Site, Hyde Park, N. Y. The usual banquet will be held on Saturday evening, at which time Everett S. Rademacher, M.D., will speak upon "The Relationships between Psychiatry and Astronomy." Dr. Alice H. Farnsworth will also describe her recent South American trip, especially that part which relates to her astronomical experiences.

Personal: Mr. Bertram J. Topham of Toronto, Ontario, is the first recipient of the newly established Chant Medal to be awarded to an amateur observer for outstanding contributions to astronomy in Canada. Mr. Topham has been an indefatigable observer of variable stars since 1937, and he has actively participated in aurora, meteor, nova search, and comet search programs. He has also turned his hand to telescope making, and is much interested in the popularization of astronomy. The award of this medal to Mr. Topham is well deserved, and other amateur astronomers extend to him their congratulations.

Observers and Observations: With the return of more clement weather, the total of observations received during the month of March has noticeably increased over that of previous months. Sr. F. J. Escalante of Mexico City, Mexi-

co, has recently joined the staff of the newly created Mexican National Observatory at Cholula, about sixty miles distant from Mexico City. There he will be able to devote more time to the observation of variable stars under the direction of Sr. Luis E. Erro, Director of the newly established observatory.

We are pleased to note the return to the ranks of active observers of Messrs. Felix de Roy of Antwerp, Belgium, and H. E. Houghton of Cape Town, South Africa. It has been some months since reports have been received from R. G. Chandra of Bagchar, India, or Eppe Loreta of Bologna, Italy. The Mosman 4½-inch telescope has been loaned to D. C. Taulman of Stephenville, Texas.

The list of contributors during the month of March follows:

Observer	Var.	Obs.	Observer	Var.	Obs.
Albrecht	12	12	Kelly	13	18
Ball, A. R.	11	11	Knott	1	1
Ball, J.	23	26	de Kock	13	269
Bappu	31	61	Koutz	10	10
Blunck	9	11	Lovinus	6	6
Bouton	29	29	Mason	19	21
Brocchi	12	22	Maupome	42	44
Buckstaff	7	11	McPherson	9	9
Cave	11	11	Millard	18	18
Cilley	39	52	Milnes	7	9
Cousins	25	99	Nadeau	3	3
Diedrich	7	7	Parker	15	15
Escalante	60	88	Parks	22	39
Fernald	79	161	Peltier	81	129
Ford	9	9	Prinslow	2	2
Franklin	13	14	Purdy	8	8
Griffin	48	48	Renk	4	4
Halbach	29	39	Rosebrugh	17	39
Harris	54	54	de Roy	9	36
Hartmann	104	144	Schoenke	3	3
Hildom	12	15	Sill	11	11
Holmes (Mrs.)	5	5	Smith, F. P.	4	5
Holt	137	255	Stahr (Miss)	12	17
Houghton	46	68	Taulman	30	58
Howarth	14	14	Topham	70	70
Irland	15	19	Toyek	1	1
Jones	30	41	Webb	20	22
Kearons (Mrs.)	70	161			
			Totals	55	2354

April 12, 1941.

Comet Notes

By G. VAN BIESBROECK

All the comets that were under observation in the early months of the year have now vanished: either they were lost in the vicinity of the sun or became too faint to be further recorded.

The periodic comet 1930 VI (SCHWASSMANN-WACHMANN), which was missed in 1935-1936, will apparently remain unobserved also at this second apparition since the discovery in 1930. My efforts for locating it in the morning sky with the help of F. R. Cripps' ephemeris (p. 219) have been unsuccessful. The position is now too close to the sun. Later in the summer the conditions become somewhat less disadvantageous and another trial should be made.

Another periodic comet is soon to be expected in the morning sky; it is 1925 II (SCHWASSMAN-WACHMANN), which is the peculiar object having a nearly circular orbit with a period of 16 years. It will, however, remain in reach of larger instruments only.

Williams Bay, Wis., April 11, 1941

Notes from Amateurs

Amateur Astronomers Association of New York

This month marks the highest membership in the history of the society since the depression—412 paid-up members including 56 life members. The past year has been notable for the increased public interest in our activities, resulting in a substantial improvement in membership and financial condition.

In addition to our regular meetings twice each month, we have had two very successful field trips recently.

On February 8, 50 members went to New Haven, Conn., for a joint meeting with the New Haven Astronomical Society, and inspection and observation at Yale Observatory. Comet 1941 *c* was observed under fine conditions through the nine-inch Reed refractor.

On March 22, 95 persons visited Princeton Observatory, where Dr. Newton Pierce showed the Orion nebula and a globular cluster in Canes Venatici. Observing conditions were perfect.

Our Third Annual Dinner on April 2 was attended by over 125 persons, twice as many as last year. On this occasion 89 designs were displayed which were entered by members in a competition to select a design for an official A.A.A. emblem and pin. Final selection will be made by vote of all the members through the mail, and a prize has been donated for the winning design.

Astronomical motion pictures will be shown at our annual meeting on May 21. Activities scheduled for the summer are as follows:

May 30-June 1, Annual Field Trip.

July 4-5-6, Third National Convention of Amateur Astronomers. National Capital A.A.A., Washington, D. C.

August 30-September 1, Annual Field Trip. Blue Mountain Reservation, Peekskill, N. Y.

All amateurs from the northeastern states planning to attend the convention in Washington are invited to communicate with us, because we expect to procure a special railroad car for this trip.

CHARLES A. FEDERER, JR., *Secretary*

Telescopic Appearance of Mars in 1939

In July, 1939, the planet Mars was nearer to the earth than at any time within the last 15 years, and, even to the unaided eye, it was a thing of great beauty, shining like a wonderful bright red star in the sky all through the night.

On almost every clear night during 1939, between the first of May and the last of November, I observed the planet through a small telescope, a W. & D. Mogey instrument, having a 3½-inch object glass of 50 inches focal length, using most of the time a power of 250 X, sometimes 150 X when the atmosphere was unfavorable. More than 100 drawings showing various markings which were visible were made.

It is possible that the appearance of the planet through a telescope of this size would be of some interest to other users of telescopes who would like to make a comparison with their own observations even though they use much larger or smaller instruments, and for this reason we present here a description of some of the features that were seen.

In the following delineations the figures immediately after the date refer to the longitude of the central meridian of the visible disc.

June 21, 118°. Although the south pole was leaning towards the earth, a portion of the north polar cap was faintly visible. While I was observing Mars at this time a thin cloud passed across the field of the telescope. It was noticed that when seen through the cloud the visibility of this faint polar cap was increased. I am not certain why this should be so, but it is probable that the cloud served as something like a color filter causing the polar cap and the surrounding area to have greater contrast. A streak was visible across the southern portion of the disc, as there often is, however, it seemed rather dark for this longitude. Near its center was Aonius; the east end of the streak was the west end of Mare Sirenum. The north polar cap was noticed again decreasing in size on June 29, July 30, 0h 15m, July 30, 23h 30m (C.S.T.), when it was last seen.

June 27, 82°. With the exception of the south polar cap which was surrounded by a thin gray line, the disc was almost completely blank.

July 6, 345°. A gray line, faded along its northern boundary, was around the south polar cap. East of the central meridian was a gray spot, Fastigium Aryn, very easy to see; streaking westward from this spot was the long, narrow, dusky streak, Sinus Sabaeus.

July 10, 328°. West of the central meridian, the conspicuous triangular shaped Syrtis Major was visible; while Fastigium was near the east limb; connecting them was the streak Sinus Sabaeus. Another streak was noticeable running from Syrtis to the east side of the south polar cap, probably Hellespontus. A third streak, Mare Tyrrhenum, extended west from Syrtis to the edge of the visible disc.

July 11, 305°. The features noticed were nearly all those seen on July 10, and included Syrtis Major, Sinus Sabaeus, Hellespontus, Mare Tyrrhenum, and the south polar cap which was bordered with a thin gray line darker near the east end. In addition to these, a streak from Syrtis to the west side of the south polar cap was so faint and difficult to see that it was impossible to be certain whether or not a portion of its course was broken. It seemed to be a darkening of the east boundary of Mare Hadriacum. This together with Hellespontus had much the appearance of the famous canals as shown in drawings made from views through very powerful telescopes favorably situated. Fastigium Aryn had disappeared around the east limb.

It may be well to mention here that on July 14, 292°, the region west of and adjoining Syrtis was unusually bright. This was especially noticeable when seen through a yellow filter while using a power of 150 X.

July 20, 218°. Much of the southern hemisphere was darkened a dusty-gray, and the region of Mare Cimmerium tapered northward into a point northwest of this point was a little black spot, Trivium Charontis. This was seen on several nights around this time, and, although one night it was quite sharply defined, it was very small, so that when this portion of the planet was next observed, which was on August 27, the distance was so great that little Trivium Charontis was not visible.

July 31, 108°. The south polar cap was very distinct and from it a dark

streak reached to near the southeast limb. Although the location of the famous Solis Lacus was west of the central meridian, it was not visible through the 3½-inch telescope.

August 6, 87°. With the exception of the south polar cap the disc was almost blank. The center of the southern portion of the disc included the region of Solis Lacus; not a trace of this Sun Lake could be seen.

August 12, 14°. A spot pointed on its northern end rounded on the southern end was Fastigium Aryn; a narrow line from it to the west limb was Sinus Sabaeus. In the southeast quadrant Mare Erythraeum and a part of Margaritifer were shaded a soft gray.

August 17, 294°. A pointed marking in the northern hemisphere was Syrtis Major. This is the most conspicuous and interesting marking to see through a small telescope. Three streaks radiated from Syrtis; to the east, Sinus Sabaeus; to the west, Mare Tyrrhenum; and to the east side of the south polar cap, Hellespontus.

August 21, 280°. The markings visible were nearly the same as those seen on the preceding date, but a portion of the dark area near or at the east end of Mare Cimmerium with a broad-based pointed projection on its northern side had come into view near the west limb.

At the next opposition of Mars, in October, 1941, I hope again to study its various aspects. At that time the diameter of the planet is to be not much less than it was in 1939, and since it is to be in a more northern declination, and therefore at a higher elevation above the horizon where atmospheric disturbances should be reduced, the 1941 appearance should be quite favorable.

OSCAR WILSON.
Winchester Road, Lexington, Kentucky, February 15, 1941.

Communications and Comments

Under this heading we shall publish from time to time such material as does not properly fall under any of the established headings of this journal. Here, too, may be found, when occasion arises, articles which the editor may not be willing to give sanction to but which, nevertheless, may be provocative of thought along new lines.

Electromagnetic Vortices

By C. O'CONNOR

The motions of astronomical bodies disclosed by Keplerian laws have two explanations in modern theories—one proposed by Newton and the other by Einstein. The Newtonian theory assumes that every particle in the universe has an inherent attraction for every other particle. Einstein's theory assumes that every body in the universe causes a distortion or warp in a space-time continuum. Both theories postulate a vacuous space in which light is the propagation by luminous bodies of swarms of discrete particles at a constant velocity. Neither theory attempts to explain the observed existence of electromagnetism in all material bodies. Both theories ignore common characteristics of Nature, rotational motion and its corollary, periodicity.

Fundamental differences exist between modern theories of electromagnetism and the phenomena of radiant energy. There is experimental evidence that light and radiant energy in general are propagated in discrete quantities or quanta, and

there is also valid evidence that this propagation is in the form of waves.

In one physical concept the nucleus of an atom consists of a balanced arrangement of electrons and protons around which other electrons revolve in definitely regular electromagnetic orbits governed by Kepler's laws. This nuclear arrangement, however, does not conform to Coulomb's law. In another concept, the atomic nucleus is a vibrator that produces a system of surrounding waves which have definite regularity corresponding to the electronic orbits of the other theory.

A common trait of natural phenomena is periodicity, or recurrence of physical states or conditions. Most important scientific discoveries and much of our knowledge of Nature have come through investigation of periodicities. Kepler's laws in astronomy, Mendeleef's and Moseley's laws in chemistry and the laws of wave motions in physics, all are periodic laws.

Periodicity is definitely related to vibration and dynamic Nature is in a perpetual state of vibration. All rotating bodies are vibrators and the sources of astronomical and atomic periodicities may be traced to rotational motions. A universe devoid of periodicities is inconceivable.

Kepler thought his laws were related to magnetism which he believed to be a form of vortical motion and he postulates the rotation of the sun which was later confirmed by Galileo's observations. Descartes also proposed a vortical theory of the solar system but it was displaced by Newton's theory.

Through a modification of Descartes' theory of vortices, adapted to include Kepler's laws, it is possible to explain planetary motions as well as the phenomena of radiant energy in a new electromagnetic wave concept which reconciles the differences between the several theories of astronomy and physics.

The basic assumption of the modified vortical theory is that space is a substantial plenum in which vortical motion occurs. In some instances the motion would be stabilized or structural, as in the case of suns, planets, and atoms. In other cases the motion would be unstable, as in electrical discharges or sparks, lightning, temporary magnets, etc. Since vortical motion connotes periodicity, the theory would explain vibration.

Solar system bodies often have been compared to electromagnets, and planetary orbits are comparable with the concentric rings which surround wires carrying electricity. The sun may be considered as a great stabilized electromagnetic vortex which radiates a continuous succession of spinning ring-waves in which planets move in obedience to the laws discovered by Kepler. Planets would contain similar vortices and atoms would be vortices with similar characteristics.

To account for planetary motions in terms of vortical motion or electromagnetism, the sun's electromagnetic energy must be equivalent to gravitational mass. The relative mass of the sun is proportional to a Keplerian energy constant for the solar system, $2\pi DV^2$ or PV^3 where V is orbital velocity, D is planetary distance, and P is planetary periodic time. The value of the constant in mile/second units is about 2×10^{11} or in cm/s. units about 8.3×10^{20}. This constant is numerically equivalent to the square of the sun's radius multiplied by its average speed of rotation. (From observed data this mean speed is about 1.08 m.p.s. or about 1.73×10^5 cm/s. and the average time of surface rotation, mean of observed data, is about 2,500,000 seconds.)

The largest electromagnetic waves radiated by the sun would have an initial amplitude proportional to the radius of the sun. The initial wave intensity would be as the square of this amplitude and the sun's energy as an electromagnetic vortex would be proportional to R^2s, where R is radius of the sun and s is the

average speed of surface rotation, a component of vortical motion. For the sun R^3s is about 8.2×10^{26} in cm/s. units.

Thus the sun's index of electromagnetic energy would be equivalent to the index of its gravitational mass, or $2\pi DV^2 = PV^2 = R^2s$.

The solar vortex would have a series of interior zones of rotation with speeds increasing inwardly from about 1 + miles/sec. as observed at the surface to possibly 186,000 m.p.s. at the center. In addition to rotation, the zones might have a slow oscillatory motion, planes of rotation swinging periodically above and below the equatorial plane, the oscillation being slower at the surface than at the center. This oscillation would account for the irregularity of the sun's surface rotation and also for the periodic formation of sunspots.

The internal pressure developed by the vortex would result in radiation or projection into surrounding space of pressure waves in the form of exterior zones of rotation propelled outward with the velocity of light. These exterior zones, initially spheroidal, would become flattened out eventually into rings, like those around Saturn, by the centrifugal force developed by their rotation. The exterior zones (or electromagnetic pressure waves) would have an initial rotational speed proportional to the radius (R) divided by the square root of the sun's average time of surface rotation ($T^{\frac{1}{2}}$). Subsequent rotational speed of the zones would decrease proportionately to the square root of the distance from the source. *E.g.*, Earth (mile/sec.) 432,000 mi. $/(216)^{\frac{1}{2}}$ $(2{,}500{,}000$ sec.$)^{\frac{1}{2}} = 18.5 +$ m.p.s.

Reaction between electromagnetic vortices and surrounding space would be such that the radiation would form a series of wave trains or standing waves of fixed lengths, corresponding to orbital radii.

It has been found that planetary elements are paired, that is, the products of paired distances, periods, or velocities tend toward constant values. *E.g.*, (mile/sec.)

	Mercury and Saturn		Constants (approx.)	Venus and Jupiter
Distances (approx.)	$(36 \times 10^6) \times (885 \times 10^6)$	$= 32 \times 10^{15} =$		$(66 \times 10^6) \times (483 \times 10^6)$
Periods	$(7.6 \times 10^6) \times (928 \times 10^6)$	$= 71 \times 10^{14} =$		$(19.4 \times 10^6) \times (373 \times 10^6)$
Orb. vels.	29.7 × 6	= 178 =		21.8 × 8.1

In cm/s. units the above distance "constant" is about 8.2×10^{26} or numerically equivalent to the solar system energy constant PV^2.

Similar constants are found in the wave computations, where the constants are products of wave-lengths and wave-amplitudes.

Wave-lengths and frequencies at planetary distances are obtained from planetary numbers derived through the velocity of light: $cD/R = N$, where N is planetary number, c is distance traveled by light in one second, D is planetary distance measured in sun radii and R is radius of the sun. The frequency (f) of a wave at planetary distance would be given by $(N_1N_2)/N = f$ where (N_1N_2) is the paired product of planetary numbers (*i.e.* about 32,000). *E.g.*, Earth: $32{,}000/93 = 344 = f$; wave-length = 186,000 mi./344 = 540 miles. Wave-amplitude at planetary distance would be as R/D and wave intensity as $(R/D)^2$ where R is radius of sun and D is planetary distance in sun radii.

Planetary Vortices.

In the interior of every planet would be a vortex similar to the solar vortex, but with lower maximum rotational speeds at the center. In bodies having no satellites these vortices might be very feeble. The radius of the central vortex

of a planet-satellite system would be given $R/\sqrt{(PV^3/pv^3)} = r$ where R is radius of solar vortex, r is radius of vortex at center of planet, P is planetary periodic time in seconds, V is planetary orbital velocity, p is periodic time of satellite in seconds, and v is satellite's orbital velocity.

E.g., Earth $432{,}000/\sqrt{332{,}000} = 750$ miles.

Wave frequency (J) at the surface of the central vortex of a planet would be given by $F/\sqrt{(PV^3/pv^3)} = J$, where F is wave frequency at surface of sun, *e.g.,* Earth: $74{,}400/576 = 129$ vibrations per second. In the electromagnetic vortices frequencies decrease directly as distance from source and (j), the frequency rate at the surface of the Earth, would be as $129/5.3 = 24$ per sec.

Control of planetary motions by solar waves is indicated by the formula $u(q/Q)^{7/6}\ (j/F)^{1/4} = s$, where s is planet's equatorial speed of rotation, u is orbital velocity of theoretical body revolving around planet's surface and q its periodic time; Q is revolutionary period of theoretical body around sun's surface; j is wave frequency of planetary vortex at surface of planet and F is wave frequency at sun's surface, *i.e.,* about 74,000 vibrations per sec. The formula yields approximate equatorial speeds of primaries of all planet-satellite systems.

E.g., Earth: (mile/sec.) $4.9\ (5100/10{,}000)^{7/6} \times 24/74{,}400)^{1/4} = .29$ m.p.s.

Galileo's law of terrestrial gravity may be related to vortical motion. The initial and subsequent average velocities of freely falling ponderable bodies near the earth's surface can be computed (approximately) in terms of the earth's rotational speed: $ts/(c/a) = v$ where t is time of fall in seconds, s is planetary rotational speed (in feet or meters per second), v is average velocity of fall (in feet/sec. or meter/sec.). c is distance traveled by light in one second and a is amplitude of the solar wave at planetary distance, *e.g.,* Earth: (feet/sec.)

1 sec. $\times$ 1526 f.p.s./(186,000 mi./2,000 mi.) = 16.4 feet/sec.

Corresponding initial speeds of falling bodies found through the formula for the sun and primaries of other planet-satellite systems differ from those given by the gravitational theory, as shown below: (feet/sec.)

Gravitational:	16.2	6	45	18.5	432
Planets:	Earth	Mars	Jupiter	Saturn	Sun
Vortical:	16.4	5	84	34	13,000

In the case of the sun, according to the formula, initial speed of fall would be greater than the surface rotational speed, and the body would tend to move off toward a tangent to the surface, or away from the sun's center.

Physically, no ponderable body of ordinary size could reach the sun. It would be reduced to a gaseous state and be repelled by the sun's radiation.

Electromagnetic interpretation of Kepler's laws would apply also to atomic physics. In modern theories, electrons, protons, neutrons, and hosts of other particles are simply inferences drawn from photographic evidence. When lines on a photograph curve in one direction they are supposed to have been made by particles of negative electricity and when they curve in the opposite direction they are supposed to have been made by particles of positive electricity.

In the vortical theory new inferences are drawn from the same facts and all the phenomena are accounted for in terms of electromagnetic vortices rotating in the same or opposite direction from the rotation of the magnetic field in which they move. Neutrons would be formed by oppositely rotating vortices becoming jammed together through collision and having their rotation neutralized or stopped.

Numerous inconsistencies and contradictions in modern electronic theories imply that macrocosmic laws do not apply to microcosmic systems. In the vortical theory the same consistent laws apply to all systems regardless of size. A solar vortex would be a great laboratory continuously producing and radiating countless numbers of atomic vortices which would be collected in the exterior magnetic orbits. Atomic vortices would be similar structures differing only in size. Among atoms of highest energy would be "light atoms" or vortices that generate light waves, with nuclear systems having surface rotational speed of about 1.73×10^5 cm/s. increasing to possibly 3×10^{10} cm/s. at the center. These light vortices would radiate ring-waves in all direction with the velocity of light. The amplitudes and wave-lengths would of course be of atomic dimensions.

The elements of matter would be atomic vortices having a lesser number of nuclear rings, or rotating zones, than the light vortices, with lower maximum rotational speeds. These material elements could be formed in the sun through stripping of nuclei of higher energy atomic vortices by violent collision, the processes being similar to those observed in the disintegration of our radio-active atoms.

It has been observed that uranium, the highest element of matter, ejects particles with velocities approaching that of light, hence it might be assumed that the innermost nuclear zone has a rotational speed about as that of the light atom or the sun.

The solar system has "quantized" orbits similar to those of the Bohr model atom, that is, their intervals are as the squares of simple numbers. The Bohr model has been succeeded by a wave model, which even more strikingly resembles the solar system. According to the principle of electromagnetic vortices that products of wave-amplitudes and wave-lengths form constants, atomic orbits, like planetary orbits, would be paired, dimensions being as reciprocals of solar system dimensions. On the basis of pairs the size of the solar system can be computed as follows:

A body revolving in a Keplerian orbit around the sun's surface, with orbital radius of 6.95×10^{10} cm., orbital velocity of 4.38×10^7 cm/s., and periodic time of 10,000 seconds, would pair with a Keplerian body about 12×10^{15} cm. from the sun, with orbital velocity of about 1×10^5 cm/s. and periodic time of about 73×10^{10} seconds, or approximately 23,000 years.

In any electromagnetic vortex the distance of the outermost orbit would be given by $cR/s = L$, where c is velocity of light, R is radius of central vortex, s is average surface speed of rotation (invariably about 1.73×10^5 cm/s.) and L is distance in centimeters.

The initial amplitude of the solar vortex is as the radius of the sun (about 6.95×10^{10} cm.). As amplitude decreases directly as distance, the amplitude of the outermost planetary wave would be about 4×10^5 cm.

An atomic vortex corresponding to the solar vortex would be like a miniature solar system, dimensions being as reciprocals of solar system dimensions. This vortex would be a "sol-atom" which would generate electromagnetic waves from ultra-violet to "cosmic rays." The radius of the nucleus would be as the reciprocal of the radius of the whole solar system, or about $1/(12 \times 10^{15})$ cm. and the radius of the whole atom would be as the reciprocal of the sun's radius, or about $1/(6.95 \times 10^{10})$ cm. The atom's nucleus, like the sun, would have an average speed of surface rotation of about 1.73×10^5 cm/s., the speed increasing inwardly to the center to possibly 3×10^{10} cm/s. The energy constant of the sol-atom,

PV^3 or R^2s would be as the reciprocal of the solar system constant, or about $1/(8.3 \times 10^{28})$ (in cm/s. units). This constant is as the product of wave-amplitude and wave-length and corresponds to Planck's constant $h = 6.56 \times 10^{-27}$) and can be used in a similar manner to determine relative wave energy.

Through the solar system formula $R/T^{\frac{1}{2}} = V$, where R is radius of sun, T is average time of surface rotation and V is orbital velocity of a theoretical Keplerian body revolving around the surface of the solar vortex, it is found that the orbital velocity of such a body revolving around the surface of the sol-atom's nucleus would be about $1/(6.5 \times 10^5$ cm/s.) in periodic time of about $1/(3 \times 10^9)$ of a second.

Wave-lengths in the sol-atom would correspond to harmonic orbital radii and would be as reciprocals of wave-amplitudes in the solar system. The initial wave-amplitude in the solar system is proportional to the radius of the sun. The reciprocal of this is $1/(6.95 \times 10^{10}$ cm.) which would be the shortest wave in the sol-atom system at the surface of the nucleus. The frequency would be about 2×10^{21} vibrations per second. The wave-length at the outer boundary would be about $1/(4 \times 10^5$ cm.) with frequency of about 12×10^8 vibrations per second. Lower frequencies and longer wave-lengths are found in the chemical elements, or atomic vortices of matter. Ordinarily these feeble waves go undetected but become evident in excited gases through resonance with incident light.

Basic Keplerian laws for atomic vortices are the same as for astronomical vortices and the elements of material vortices (atoms of matter) can be computed through the following formulae:
$R/(W/w)^{\frac{1}{2}} = r$, where R is radius of sol-atom, r is radius of material atom, W is atomic weight of sol-atom (estimated 250), w is weight of material atom. $F/(W/w)^{\frac{1}{2}} = J$, where F is wave-frequency of sol-atom and J is corresponding frequency of material atom. Atomic weight is an energy factor related to mass. $PV^3/(W/w) = pv^3 = R^2s/(W/w) = r^2s$.

Relative energy (in cm/s. units) of the hydrogen vortex computed through the above formulae is about $1/(2 \times 10^{29})$. Relative energy of the sun is about 8.3×10^{28}. The quotient of these two factors is about 1.6×10^{56}. The mass of the hydrogen atom is currently estimated at about $1/(6 \times 10^{23}$ grams), and the mass of the sun at about 2×10^{33} grams. The quotient of the two factors is about 12×10^{56}.

The figures in this outline are used chiefly for illustration and are necessarily approximate and tentative. However, the dimensions are of the order of those calculated by other methods based on observation and experiment. Uniform and consistent changes in dimensions would not affect the underlying principles.

(NOTE: All electromagnetic vortices would have the same average speed of surface rotation, about 1.73×10^5 cm/s., or about 1.08 mile/sec. Rotational speeds at the centers would vary as indicated by their Keplerian energy factors.)

The principles of resonance would govern the reactions of material vortices, or atoms of matter, to waves radiated by light vortices, in a way somewhat analogous to the selective reactions of tuning forks to sound waves.

The amplitudes of specific rings in the atomic vortex would be increased by the frequency of impact of waves radiated by the incident light vortices having the same frequencies. This would account for the color effects shown in excited gases. Each kind of atom would have characteristic frequencies that would respond to appropriate frequencies of the incident light waves, whether the latter were produced by the stabilized light atoms or the unstable or temporary vortices

that are the commonest sources of light.

In solids where atomic freedom of movement is restricted, resonant amplification of affected rings by incident light waves would result in sudden expansion of the excited atoms which would cause them to eject loosely held particles or electrons at speeds proportional to the wave velocities of the resonating vortices.

In the disintegration of radio-active atoms, where the atoms are shattered by collisions of extreme violence and separated into parts, the outer part of the disrupted nucleus would form a new vortex with the ring having the highest rotational speed becoming the central ring in a new nucleus. The remaining, or inner part of the old nucleus which had lost outer rings, would develop a new series of rings or zones regressing in rotational speed to about 1+ m.p.s. at the surface.

All sources of light, including the sun, continuously produce great numbers of unstabilized or temporary vortices which radiate ring-waves in all directions. These waves are governed by the familiar laws of the wave theory of light.

Most terrestrial sources of light are unstable vortices due to some kind of combustion, or the temporary stabilized and controlled vortices produced by electromagnetic machines. The particles expelled by these vortices are themselves smaller temporary vortices of low rotational speeds corresponding to electrons.

In X-ray and similar apparatus, small temporary vortices are discharged from a cathode to an anode or target, and the shattering of these small vortices upon impact sets up pulsations in the space plenum. These pulsations do not rotate and cannot be deflected in a magnetic field, differing in this respect from the ordinary rotating ring-waves which accompany existing vortices.

Space pulsations are produced also by wireless or radio apparatus, where the space plenum is bombarded systematically by temporary electromagnetic vortices or "sparks." The waves thus produced are somewhat analogous to sound waves produced in air by the systematic emission of "puffs" from the vents of sirens.

Electrical and magnetic phenomena generally may be described in terms of vortical motion based on the principle discovered by Ampere. Wires carrying electrical currents in the same direction are attracted and wires carrying currents in opposite directions are repelled. If the wire be divided imaginatively into separate sections like disc magnets, the sections would be analogous to individual vortices. They would attract each other when rotating in the same direction and repel each other when rotating in opposite directions. This analogy would apply to atomic and molecular vortices.

Induced electromagnetism is analogous to the reactions of two wheels. When the rim of a rotating wheel tangentially contacts the rim of a wheel at rest, rotation is started in the latter in an opposite direction. Or if both wheels originally were rotating in the same direction and one wheel was much larger or rotating at much higher speed, the direction of rotation of the smaller wheel would be reversed.

An electrical machine of any kind is an instrument that produces vortical motion of very high internal or nuclear speed. Electromagnetic vortices of high energy, whether temporary (unstabilized) or stabilized, would have internal or nuclear rotational velocities approaching 3×10^{10} cm/s. The nuclear vortices are surrounded by external zones of rotation. When confined to wires or conductors the vortical motion seeks to escape from an overcrowded environment, the escaping motion being electricity. Magnets, electromagnets, metallic wires or copper coils, carrying electricity, will produce high rotational motions in neighboring wires or coils through the principle of resonance: the external or ex-

terior rotating zones of the active primary will amplify the less active or weaker vortical motion of the atoms and molecules in secondary wires or coils, producing temporary vortices in them having nuclear speeds of rotation up to 3×10^{10} cm/s. This amplified vortical motion (electricity) also will seek to escape from its confines.

In ordinary electric cells or batteries, the atoms of the component metals combine to form nuclear vortices of high rotational speeds (ions) and these seek escape through the connecting wire whose atomic and molecular motions are thereby amplified, producing temporary vortices of very high nuclear rotational speeds (electricity).

After confirming some of Ampere's experiments, Michael Faraday wrote: "All the usual attractions and repulsions of the needle by the conjunctive wire are deceptions, the motions not being attractions or repulsions, nor the result of any attractive or repulsive forces, but a result of a force in the wire which instead of bringing the pole nearer or farther from the wire, endeavors to make it move around in a never ending circle and motion whilst the battery remains in action."

That is a description of vortical motion.

Stoney showed that the chemical elements could be plotted in a logarithmic spiral with a sesquiple ratio. Solar system distances, periods and orbital velocities can be similarly plotted. The geometrical pattern of Nature is a continuous evolution of the spiral form, "always changing but ever the same." It is found everywhere from spiral nebulae to electrons and runs throughout terrestrial flora and fauna. It might be traced into psychology and sociology.

The Universe is in a continuous state of vibration and might accord with the principle quoted by Tschirner:

"If one part of any system connected either by material ties, or by the mutual attractions of its members, be continually maintained by any cause, whether in the constitution of the system or external to it, in a state of regular periodic motion, that motion will be propagated throughout the whole system, and will give rise, in every member of its and in every part of each member, to periodic movements executed in equal period with that to which they owe their origin, though not necessarily synchronous with them in their maxima and minima."

Whenever we hear the melodies of singing birds or listen to orchestral symphonies, we hear, like Pythagoras, the Music of the Spheres.

1121 Paloma Ave., Burlingame, California.

General Notes

Dr. Annie J. Cannon, well known throughout the world among astronomers for her monumental work in the classification of stars according to their spectra, died on April 13, at the age of seventy-seven years. An account of her valuable contributions to the science of astronomy will be given in a later issue.

Dr. Max Mason, Chairman of the Observatory Council of the California Institute of Technology, delivered the annual public lecture before the Eta of California Chapter of Phi Beta Kappa, at the University of California at Los Angeles, on April 2. The subject of Dr. Mason's address was "The Telescope and our World Today."

Dr. Annie J. Cannon, well known throughout the world among astronomers fornia, Berkeley, delivered an Alexander F. Morrison lecture of the Astronomical Society of the Pacific at the University of California, Los Angeles, on the evening of April 23, 1941. The subject of the lecture, which was fully illustrated with sildes, was "The Milky Way."

The Variable Star Section of the New Zealand Astronomical Society has recently issued Circular No. 21, which contains the results of observations of variable stars during the second half of the year 1940. These observations are the more important because similar work is necessarily practically at a standstill throughout a large part of the world at present.

The Rittenhouse Astronomical Society held its monthly meeting on Thursday, April 17. After a dinner the following program was given: Dr. Charles P. Olivier, "The Work of The Flower and Cook Observatories"; Dr. Roy K. Marshall, "The Spectrographic Program at the Cook Observatory"; Dr. Philip W. Taylor, "Asymmetry in The Light Curves of Eclipsing Variables."

Teaching of Astronomy

The response to the letter addressed to the teachers of Astronomy has been wide spread. Many interesting and valuable points have been presented and the questions raised have been too numerous to answer individually, but they will be answered collectively at a later date.

There are many other teachers who we feel have valuable contributions to make to the discussion. May we urge that they send in their statements at once so that our study may be as complete as possible before the end of the present college year.

JOHN H. PITMAN.

Sproul Observatory, Swarthmore, Pennsylvania.

Yerkes Astronomical Meetings

As stated in the preceding issue (page 227), the Yerkes Observatory is arranging a symposium on "Astronomical Spectra" in connection with the celebration of the fiftieth anniversary of the University of Chicago next September. The dates for the symposium are September 10-12 following the annual summer meeting of the American Astronomical Society at the Yerkes Observatory from September 7-10. This schedule, therefore, makes it possible and convenient for members of the American Astronomical Society to attend the meeting of the society and the symposium and those, who wish to do so, are cordially invited by Dr. Sturve to remain.

Following is a tentative program of symposium on Astronomical Spectra:

WEDNESDAY, SEPTEMBER 10

9:00-11:30 A.M.	Normal Stars: Continuous Spectrum	
	1. Theory	Wildt, 1 hr.
	2. Observation	Williams, 1 hr.
	3. Discussion	½ hr.
2:00- 4:30 P.M.	Normal Stars: Spectral Classification	
	1. The General Problem	Morgan, 1 hr.
	2. White Dwarfs, sub-dwarfs and main-sequence stars	Kuiper, 1 hr.
	3. Discussion	½ hr.
8:00- 9:30 P.M.	Long-Period Variable Stars	Merrill, 1½ hrs.

THURSDAY, SEPTEMBER 11

9:00-11:30 A.M.	Normal Stars: Absorption Lines
	1. Line Contours and Curves of Growth.....Dunham, 1 hr.
	2. Composition of Stellar Reversing Layers....Russell, 1 hr.
	3. Discussion .....½ hr.
2:00- 4:30 P.M.	Absorption Lines
	1. The Spectrum of the Sun .....Menzel, 1 hr.
	2. The Spectrum of Interstellar Gas .....Dunham, 1 hr.
	3. Discussion .....½ hr.
8:00-10:30 P.M.	Variable Stars
	1. Variable Stars .....Schwarzschild, 1 hr.
	2. Novae, Wolf-Rayet Stars and Related Objects .....Swings, 1 hr
	3. Discussion .....½ hr.

FRIDAY, SEPTEMBER 12

9:00-11:30 A.M.	Nebulae
	1. The Spectra of Gaseous Nebulae .....Wyse, 1 hr.
	2. The Theory of Nebular Emission.....Menzel, 1 hr.
	3. Discussion .....½ hr.
2:00- 4:30 P.M.	Peculiar Stars
	1. Be Stars and P Cygni Type Stars.....Merrill, 1 hr.
	2. Extended Atmospheres .....Sturve, 1 hr.
	3. Discussion .....½ hr.
Evening	Lecture in Chicago.

"I Am An American" Day—1941

Although this is a scientific journal, it is also an American Journal. Hence it is fitting and desirable that the following proclamation should appear in it. EDITOR.

BY THE PRESIDENT OF THE UNITED STATES OF AMERICA

A PROCLAMATION

WHEREAS Public Resolution No. 67, approved May 3, 1940 (54 Stat. 178), provides, in part:

> That the third Sunday in May each year be, and hereby is set aside as Citizenship Day and that the President of the United States is hereby authorized and requested to issue annually a proclamation setting aside that day as a public occasion for the recognition of all who, by coming of age or naturalization, have attained the status of citizenship, and the day shall be designated as "I Am An American" Day.
>
> That the civil and educational authorities of States, counties, cities, and towns be, and they are hereby, urged to make plans for the proper observance of this day and for the full instruction of future citizens in their responsibilities and opportunties as citizens of the United States and of the States and localities in which they reside:

NOW, THEREFORE, I, FRANKLIN D. ROOSEVELT, President of the United States of America, do hereby designate Sunday, May 18, 1941, as "I Am An American" Day and urge that this day be observed as a public occasion in recognition of our citizens who have attained their majority or who have been naturalized within the past year. And I do call upon all Federal, State, and local officials, and all patriotic, civil, and educational organizations to join in exercises calculated to impress upon all our citizens, both native-born and naturalized, the special significance of citizenship in this Nation.

IN WITNESS WHEREOF, I have herento set my hand and caused the seal of the United States of America to be affixed.

DONE at the City of Washington this 27th day of March, in the year of our Lord nineteen hundred and forty-one, and of the Independence of the United States of America the one hundred and sixty-fifth.

(SEAL) FRANKLIN D. ROOSEVELT.

By the President:

SUMNER WELLES,

Acting Secretary of State.

Book Reviews

Webb's Atlas of the Stars, by Harold B. Webb. 9251 173rd St., Jamaica, N. Y., $4.00.

At this present time Mr. Webb's revision of the Beyer-Graff charts is something more than timely. Astronomy is usually handicapped by lack of suitable maps and the amateur has no other set now available. The *Bonner Durchmusterung* is long out of print, the *Carte du Ciel* is incomplete and not suited to an amateur, while the handy Beyer-Graff charts have been cut off by the war. This, thus, becomes the only set available.

Mr. Webb's alterations are to be commended for the most part. He has written in the Messier numbers, affixed the Greek letters to naked-eye stars, drawn the customary lines connecting the brighter stars in each constellation, plotted the AAVSO variable stars, and added the visual magnitudes to comparison stars about these last. Some of us will regret the use of 1920.0 as his epoch, the omission of the Flamsteed numbers and the NGC designations, but these do not in the least impair the fact that this atlas makes it easy to pass from the naked-eye charts to the more elaborate telescopic variety.

The paper is a soft cream which stands erasure and dew, the scale is 1 cm. to the degree and the pages cover 15 x 20° with a generous overlap. Stars are shown to 9.5 and nebulae to 13.0. The charts, printed on both sides, are bound in a book of 135 pages including a set of key charts, the AAVSO catalog of variable stars, a list of celestial objects for small telescopes, and various hints on observing.

Such charts are indispensable to the serious amateur who wishes to observe something more than the moon and major planets, and the convenient arrangement should make these charts rather useful about the professional observatory as well. Such a book has been needed for some years and Webb's Atlas comes very close to filling ideal requirements.

W. S. HOUSTON.

University of Alabama.

The Dozen System, by George S. Terry. (Longmans Green and Co., New York. Fifty cents.)

This large sized pamphlet of some sixty pages neatly bound calls attention to some unfamiliar properties of numbers. Ten, as the base for our system, is not the most ideal one because it does not contain as many factors as some other numbers do. For instance, six divides into halves and thirds; eight, into halves and quarters; sixteen into halves, quarters, and eighths; and twelve, into halves, thirds, quarters, and sixths. From this it is seen that twelve presents the most possibilities as it contains four integral factors whereas ten contains only two.

The question is whether a change to a different base is worth the trouble

and inconvenience that would go along with it. If such a change were to be made, there are three reasons why twelve should be chosen rather than any of the other bases mentioned. First, it contains more different factors; second, it is the smallest number with four divisors; and third, it has more simplifications to offer to arithmetic than have the others.

Space is not available here to show all of the arithmetical simplifications that would result. Some of the practical applications also show great advantages. For example, in the commercial field, a change to twelve would simplify many of the operations. The grocer has recognized this fact in his division into groups of twelve. In interest rates the interest per month would be one tenth duodecimally of the rate per year; *i.e.* 6% per year would be 0.6% per month. Other rates would have to be changed similarly and their duodecimal equivalents substituted as close as possible. Such changes would all be taken up by our flexible commercial money market without any trouble and only the interest-declaring securities would suffer.

Weights and measures even at the present time are a problem to those who use the English as well as the metric system. The latter system put on the dozen system basis would bring about a combination of the two and greatly simplify the scientist's arithmetical problems.

These changes, if they come at all, are going to come slowly and with great difficulty, but it seems reasonable that the advantages accruing from them will eventually be realized. Then again, with a modern world dictator in power these changes could be authorized overnight. The fate of the nations is our great problem and its solution resulting in a united world may bring about changes as great as those of our number base.

PARKER JONES, JR.

Carleton College, Northfield, Minn.

Odd Numbers, or Arithmetic Revisited, by Herbert McKay. (The University Press, Cambridge, England, and The Macmillan Company, New York. $2.50.)

At first thought it might seem that the subtitle is probably wrongly stated, that *revised* instead of *revisited* was intended. But this is not the case. The author in the use of this word says in effect that he is here looking at arithmetic again, with a somewhat more mature mind than that with which arithmetic is usually encountered for the first time. A reading of the book discloses also the fact that *odd* numbers is not be contrasted with *even* numbers, according to the usual correlation of these terms. The author wishes to emphasize that all numbers are *odd* in the sense that they possess strange, slightly hidden, almost mysterious properties, which are revealed only by a careful and thoughtful consideration of them.

The book is not a highly technical text in mathematics. The reading and comprehending of it require little more than a sense of numbers, which happily all normal persons are endowed with, and an interest in them. When one reflects upon the many ways in which one necessarily comes into contact with numbers each day, it seems strange that there should be anyone who is not interested in them.

We cannot begin to indicate the variety of aspects in which numbers are considered in this book of a little more than 200 pages. We can only say that each page is a revelation to one who may not hitherto have been led to contemplate the simple yet fascinating facts here presented. The remainder obtained by dividing any number by nine is the same as the remainder obtained by dividing

the sum of the digits of the number by nine. The sum of any number of consecutive positive numbers, beginning with unity, is the square of the number of numbers used. The sum of all the positive integers beginning with unity and going as far as we please with the sum is correctly given by one-half the product of the final number used by the number following it. Such and many other unfamiliar properties of numbers are clearly set for and explained in this book. It may be well recommended for the tpye of thinking with which it deals.

C.H.G.

Perkins Observatory Contributions. No. 14 of this series contains an extensive study of the spectroscopic variable, ϕ Persei, made by J. A. Hynek. It consists of 47 pages including a number of charts, diagrams, and tables. This same star was the subject of a paper by Dr. Otto Struve, published in the March (1941) issue of this magazine.

Publications of the Observatory of the University of Michigan, Volume VIII, No. 6.

A copy of the above-named publication has recently been received at the office of POPULAR ASTRONOMY. It is a twenty-page octavo pamphlet giving a description of The Francis C. McMath Memorial 24-inch Reflecting Telescope of the McMath-Hulbert Observatory, which was recently presented to the University of Michigan. Six full-page plates showing various features of the telescope are included. This constitutes an important addition to the already extensive equipment of the Observatories of the University of Michigan.

Astronomical Papers, Vol. X, Part II.

The publication described above has recently been issued by the Nautical Almanac Office, U. S. Naval Observatory, Washington, D. C. Copies of it may be procured from the Superintendent of Documents, Washington, D. C., for thirty cents each.

This octavo pamphlet of 125 pages contains a catalogue of 3539 Zodiacal stars, giving very accurately determined positions for the equinox 1950.0, and numerous other data concerning the individual stars. It will be of great use to workers in positional and statistical astronomy and constitutes on important addition to this notable series of papers.

Speaking of Earth, by Gertrude Gowry. (Bruce Humphries, Inc. Boston, Mass. $1.00.)

This is a small book, and is intended for young people. It consists of only 64 pages, about half of which are devoted to pictorial diagrams. In speaking of the earth, the author also speaks of the moon, the sun, and the stars. In a word, we find here a quick sketch of the most obvious astronomical lore. One, perhaps, should not expect to find absolute scientific accuracy in so simple a treatise, hence the few short-comings in this respect can be overlooked. The pictures will carry the interest and hold the attention of children for whom the book is intended, and the descriptive pages accompanying the pictures will convey such ideas as are comprehensible by them.

POPULAR ASTRONOMY

CONTENTS

MAY, 1941

FRANK CRAIG JORDAN, Oliver J. Lee 231

A TRIP INSIDE THE STARS, Theodore Eugene Sterne 236

DREAMER TO A REALIST, (Poem), Cabot Barber 242

ASTEROID NAMES, Hugh S. Rice 243

PSEUDO-SCIENE AND REVELATION, N. T. Bobrovnikoff 251

THE ADDITION TO THE WARNER AND SWASEY OBSERVATORY, J. J. Nassau 257

Planet Notes for June, 1941 259

Asteroid Notes 260

Occultation Predictions for June, 1941 260

Meteors and Meteorites 261

Contributions of the Society for Research on Meteorites: A Mathematical Formula for Meteoritic Age—Determination and its Application to the Pultusk, Poland, Meteorites; Contraterrene Meteorites; Committee Appointments.

Variable Stars 267

Variable Star Notes from the American Association of Variable Star Observers.

Comet Notes 272

Comet 1930 VI (Schwassmann-Wachmann),—Comet 1925 (Schwassmann-Wachmann).

Notes from Amateurs 273

Amateur Astronomers Association of New York,—Telescopic Appearance of Mars in 1939.

Communications and Comments 275

Electromagnetic Vortices.

General Notes 282

Personal notices,—The variable star section,—The Rittenhouse Astronomical Society,—Teaching of Astronomy,—Yerkes Astronomical Meetings,—"I Am An American" Day—1941.

Book Reviews 285

Webb's Atlas of the Stars,—The Dozen System,—Odd Numbers, or Arithmetic Revisited,—Perkins Observatory Contributions,—Publications of the Observatory of the University of Michigan,—Astronomical Papers,—Speaking of Earth.

The principal articles of this magazine, beginning with Volume 15 (1907), are listed in the International Index To Periodicals.

Y

31
36
42
43
51
57
59
60
60
61
7
2
3
5
2